# BEACH MANAGEMENT PLAN WITH BEACH MANAGEMENT DISTRICTS

HAWAII COASTAL ZONE MANAGEMENT PROGRAM
OFFICE OF STATE PLANNING
OFFICE OF THE GOVERNOR

# BEACH MANAGEMENT PLAN
# WITH
# BEACH MANAGEMENT DISTRICTS

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# EXECUTIVE SUMMARY

* A qualitative analysis of 1990 aerial photographs for the island of Oahu was conducted to ascertain the extent of beach degradation. By comparing the 1990 aerial photos with previous aerial photographs and coastal studies, it is estimated that since 1928, approximately 8 to 9 miles, or close to 15% of the sand shorelines studied on Oahu have either disappeared or have been negatively impacted by shoreline stabilization.

* Beach loss on Oahu appears to have accelerated. Of the 8 to 9 miles of beach that have been impacted, approximately half, or 4 to 5 miles, have been degraded to the point that the beach is barely existent. Of these severely impacted shorelines, approximately half, or 2 to 2.5 miles of beaches were lost in the last 10 to 15 years. The loss of sandy shoreline over this time was greater than any other period studied.

* Beach loss in the State due to hardening of the shoreline is not limited to the island of Oahu. At a visit to selected sites, beach loss or recreational impacts were found equalling 1 to 1.5 miles on Hawaii, 1 to 2 miles on Kauai, and 2.8 to as much as 6 miles of actual or imminent impacts on Maui. A thorough analysis of all the sandy shoreline on these islands would yield higher numbers.

* Beach loss in the State has been concurrent with sea-level rise. An examination of tide gauge records around the islands indicate relative sea-level on Oahu and Kauai has risen .6-.7 in/decade. Because Hawaii and Maui are sinking due to volcanic growth, relative sea-level rise for these islands has been almost double, or approximately 1-1.5 in/decade. The current trend of sea-level rise is projected to accelerate. By the year 2050, the seas around Oahu and Kauai may be rising 2.4-2.5 in/decade. Around Maui and Hawaii sea-level may rise at a rate of 2.8-3.4 in/decade. Planners should use the current rate of sea-level rise to estimate minimum beach recession rates. The 2050 projection should be used to determine maximum recession rates. Most likely, future sea-level rise will be between these rates.

* The link between sea-level rise and beach loss has serious implications. Due to the gentle profile of many beaches, a small sea-level rise can lead to a large landward movement of the waterline. At current rates of sea-level rise, a typical beach on Oahu and Kauai may recede 5 ft/decade, on Maui, 7 ft/decade and on

Hawaii, 12 ft/decade. Accelerated sea-level rise, as projected, could lead to recession on Oahu and Kauai of 18 ft/decade, on Maui of 21 ft/decade and on Hawaii of 35 ft/decade.

* Without changes in shoreline management, loss of beaches along the coast is expected to accelerate for two reasons. First, each year, a greater percentage of the State's sandy shoreline is stabilized with seawalls and revetments. Second, as sea-level rises, these hardened barriers will have an increasing influence on beach erosion because of increased interaction with the nearshore current and wave regime. At the current rate of sea-level rise, every narrow, gently sloping beach in the State with an armored shoreline could be lost within the next 50 years. At accelerated rates of sea-level rise, this problem will become critical.

* Beaches provide a buffer zone from wave activity. As seas move inland and beaches disappear, the susceptibility of coastal property and structures to wave damage is expected to increase.

* This report discusses options for the State that are commensurate with the problems associated with beach loss and sea-level rise. Effort has been made to consider solutions that are technically, legally and financially feasible. Solutions are designed to balance the benefits and burdens of each impacted party, and to respect private and public property rights. The solutions should be viewed as options that the State may or may not pursue. Implementation of some of the solutions will require determination, commitment and leadership by the State.

* Through Beach Management Districts (BMDs), erosion mitigation measures other than seawalls and revetments can be promoted. Where technical, financial and legal obstacles prevent the formation of a BMD, buried structures such as gently sloping revetments or gravel berms should be the preferred erosion mitigation option.

* There are many reasons why a coastal landowner may want to participate in the formation of a beach management district. The major benefits include increased long-term property protection from sea-level rise, and increased property values from the presence of a healthy beach adjacent to the land.

* BMDs have been formed in numerous coastal states to deal with erosion. The three most common variations include an improvement district, an overlay district

and a taxing district. Improvement and overlay districts can be valuable tools to help recover or preserve beaches. Because of the extent of shoreline degradation around the islands, taxing districts do not appear suitable for Hawaii.

* Other coastal states have used various funding schemes to pay for the costs of a BMD. This report recommends a shared cost scheme with contributions from the State, county and shoreline property owners. Exact percentages can be worked out between the State and counties at a later date. Given the proper coordination between the State and the counties, suggested cost allocation ranges are State 60% - 45%; counties - 10%; shoreline property owner 45% - 30%. Contributions from all three parties could be reduced if Federal assistance were obtained.

* A dedicated State Beach Fund could be established for the purposes of administering and contributing to the capital improvements in a BMD. Resources from the State Beach Fund may also be used for the acquisition of selected coastal property. Money for the Beach Fund could be derived from legislative appropriations, Federal programs where applicable, a shoreline property transfer fee, landowner contributions or other sources.

* A properly structured package of tax incentives, credits and fees could be used to support beach preservation. The package could include State income tax deductions for landowner contributions over a threshold amount that go towards financing a BMD. In addition, a small one time transfer tax on the sale of beachfront property would ensure a steady stream of income into the State Beach Fund. Revenues from the transfer tax would rise as shorefront properties increase in value. The tax would be paid not by current homeowners, but by future buyers of property. To make the transfer tax politically palatable, it could be linked with a small reduction in property assessments, for homeowners that are in compliance with shoreline regulation, in order to reduce the property tax at the county level. Thus, long-term shoreline property owners would benefit from the shoreline tax package.

* Beach Management Districts may not be suitable for every section of the coast. For this reason, other management strategies were developed, including regulatory proposals.

* For nonurban land, or land that has not been subdivided, a setback is proposed which is the greater of 60 feet, or 30 years times the average annual erosion rate,

or the historical range in the position of the vegetation line as measured over a 30 year period. Thus, the setback would be based on local conditions for undeveloped coastal areas. To avoid the takings issue, variances should be allowed to preserve buildable area. If a shoreline setback is greater than 60 feet, the State and counties can reduce or eliminate the economic burden on the landowner by developing a package of compensating variances. Included in the land use package may be provisions for reduced front and side setbacks, increased density of buildings, increased height and transferable development rights. In addition, the shoreline setback may be reduced for preapproved and prefinanced sand replenishment projects. The recent U. S. Supreme Court decision in Lucas v. South Carolina Coastal Council should not affect the zoning strategies developed in this report.

* A county Beach Enforcement Fund could be established to support shoreline monitoring and enforcement activities. Money for the Beach Enforcement Fund would be derived from legislative appropriations and fines for illegal activities. Money from the Fund could be used for enforcement activities and to provide subsidies to landowners to convert vertical seawalls to buried erosion control structures.

* A State agency is needed to implement and administer many of the proposed beach management programs. The agency could be established as a division, a branch, or an office. Alternatively, the agency could be formed as a unit within the Coastal Zone Management Program or the Department of Land and Natural Resources. Assuming that a division is formed, the Division of State Beaches would pursue Federal funding for erosion control projects; coordinate Federal, State, county and landowner activities concerning coastal erosion; promote, establish and administer Beach Management Districts; develop a voluntary relocation program in conjunction with the Federal Emergency Management Agency; administer the State Beach Fund; provide technical assistance to coastal landowners, the State, and the county governments; and oversee scientific research related to long-term beach monitoring, sand resources, natural process, storm activity and sea-level rise.

## TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF TABLES

# I. INTRODUCTION

The beaches of Hawaii are precious natural features that provide recreational opportunities, a healthy environment and uncompromising scenic beauty. Beaches are also an economic asset since they form the heart of the number one industry in the State, tourism. Furthermore, offshore sand bars, beaches and dunes provide important protection as a storm barrier to dissipate wave energy which may otherwise damage inland property.

Migration and natural instability of the beach is due to the influence of waves, currents, tides, storms, sea-level movements, and sand availability. These natural forces have always altered and will continue to modify the beaches of the State. It is vital that development and habitation of the coast is properly planned with due consideration to the dynamic nature of the beach environment in order to preserve this asset for future generations.

Human influences can lead to changes in a natural beach, In Hawaii, there are many sections of the coast where shoreline development has not allowed the beach to migrate. In an attempt to stabilize the shoreline, man's activities have lead to the loss or degradation of miles of sandy beaches. In this report, an estimate has been made of the total length of beaches on Oahu which have been degraded, primarily due to hardening of the shoreline. A similar summary of previous studies was performed for selected sites on the islands of Maui, Kauai and Hawaii. Several examples are documented in figures to illustrate some of the more recent coastal impacts. The estimates, preliminary assessments, and examples which are contained in this study reflect significant deterioration of Hawaii's shoreline. <u>Due to sea-level rise and extensive shoreline hardening, beach loss is likely to accelerate, unless there is a fundamental change in how the beach resource is managed</u>.

There are two major objectives of this report. First, to develop a comprehensive and coordinated management plan for the State which will help preserve pristine beaches while allowing for intelligent and safe development along the shore. The most efficient and cost effective management strategy is to plan for shoreline instability at the earliest stages of zoning when land-use policy is most effective. Through proper planning, it is possible to produce the maximum long-term societal benefit from the beach resource.

The second objective is to address the erosion problem for sections of the coast which are currently developed. For developed coastlines, the dual objective of protecting private property rights while preserving the beach becomes considerably more complex and costly. If a shoreline is developed but has not been hardened, nontraditional alternatives such as sand replenishment, buried revetments, and detached breakwaters may be appropriate in some localities. The feasibility of these alternatives is dependent, in part, on the extent coastal landowners, the counties and the State can cooperate through the establishment of a Beach Management District (BMD).

For developed coastlines where the shoreline is hardened and the beach is lost or severely degraded, efforts can be made to restore the beach. Given the proper physical, social and economic conditions, it may be possible to recover lost beaches by the relocation or removal of buildings or erosion control structures. In this report, a strategy which offers economic incentives to the landowner forms the basis of a voluntary program to move houses or erosion control structures inland.

To the extent that it is scientifically, legally and economically possible, alternatives in this report are formulated to address the concerns of the small private landowner abutting the shoreline. Some of the recommendations in this report may restrict the erosion control options of the homeowner. On the other hand, new solutions are proposed which could be viewed as beneficial to the small landowner. These include certain erosion control options which, from a practical standpoint, were never available to the homeowner, but may be feasible through the establishment of a BMD, where project costs are shared with the county, State and possibly the Federal government. In sum, while certain options such as seawalls and steep revetments will be restricted, the landowner will be given other alternatives to protect private property.

All land use options developed in this report are designed to be within constitutional limits. Legal safeguards are built into all land use proposals, including provisions for hardship and the preservation of buildable area for all zoning recommendations (i.e. retention of "economically viable use"). Many of the strategies in this report were modeled after existing regulation in other coastal states. Some of the more strict coastal regulations have had specific provisions challenged by landowners and have survived legal scrutiny. The options in this report were modified to be more sympathetic to the concerns of the small coastal landowner.

Beach management options developed in this report can be grouped into three broad categories:

1. Artificial Beach Nourishment - The section on sand replenishment discusses the concept, planning, sand resources, monitoring, maintenance, effect of sea-level rise, structures associated with nourishment, and recommendations.

2. Structural Options - This category includes seawalls, buried revetments, detached breakwaters and recommendations.

3. Regulatory Measures - Regulatory measures include zoning, voluntary relocation programs, Federal flood insurance programs, and the development of Beach Management Districts (BMDs).

While some technical aspects of sand replenishment, breakwaters, and other alternatives have been reviewed in numerous coastal reports (see e.g., Edward K. Noda & Assoc., 1989), there are practical obstacles associated with some of the options which prevent their use by the coastal landowner. Many of the obstacles, such as cost and permitting, can be overcome by the establishment of a BMD. Thus, the BMD is a land use option which would facilitate the implementation of other structural and nonstructural measures.

This report has been organized into twelve main chapters. In Chapter II, efforts are made to understand the magnitude and causes of past beach loss, to predict the extent and causes of future loss in the State, and to describe the potential problems from future sea-level movements. Before management plans can be formulated, it is necessary to define the problem. It should be known for instance, if beach degradation is confined to a few small sites or is widespread throughout the islands. In addition, the effects of a continued or accelerated rise in sea-level on the beach, the inland property, or on various types of erosion control measures should be reviewed. In Chapter III, private and public property rights in the shoreline are addressed. Since many of the proposals in this report may affect public and private groups, it is important to review the rights and duties of each party. In Chapter IV, strategies are discussed which were utilized in the formulation of structural, non-structural and regulatory options. These strategies include the formation of beach districts, the use of economic mechanisms in beach management, the enforcement of existing regulations, the streamlining of the regulatory process and offsetting burdens with benefits. In Chapter V, the concept of the Beach Management District (BMD) and the different permutations of this regulatory tool are discussed. Obstacles to the implementation of BMDs are addressed and solutions are proposed. In Chapter VI, various nonstructural and structural options are reviewed. The review of these options centers on how they would be implemented within the BMD concept. Chapter VII deals with the issue of financing the various beach management options. A scheme with shared cost by the landowner, county, State and Federal government is proposed. A shoreline property transfer tax similar to the tax in place in parts of Massachusetts is also discussed. In Chapter VIII, other regulatory options which can be implemented separately from BMDs are reviewed. These include a discussion on a voluntary relocation program based on economic incentives, and the use of zoning to address beach instability for large parcels of undeveloped land. In Chapter IX, it is recommended that a new Division of State Beaches is established to administer and implement BMDs and other programs suggested in this report. In Chapter X, efforts are made to apply the concepts developed in this report to Ewa Beach and Kahala Beach. In Chapters XI and XII, there are recommendations for improved beach management and guidelines for the implementation of these recommendations.

## II. PROTECTING HAWAII'S SHORELINE

During the 1991 legislative session, House Bill 893 proposed the establishment of Shoreline Stabilization Districts, and an extension of the shoreline setback to 150 feet in non-urban districts for new lots. Many of the recommendations in the house bill were taken from the 1991 report, Recommendations For Improving The Hawaii Coastal Zone Management Program, in realization that the Hawaii shoreline may need additional protection from current activities. This bill was supported by the Office of State Planning, the Coastal Zone Management Program, and the planning departments of Maui and Hawaii counties.

Many comments were received on the house bill, both favorable and unfavorable. Objections to the bill centered on the questionable need for additional and extensive coastal regulation. Some commentators felt that the present system of regulation appeared to work well within the counties. Others felt that there was no compelling reason for additional controls, and that the shoreline of the State was adequately protected.

This document reports that the beaches of the State do need additional protection. In this study, changes will be discussed for how the Hawaii shoreline is managed. Questions may be raised on the need for more regulation, additional procedures or a new government agency. However, it is believed that the current weight of scientific evidence warrants a change in shoreline management.

Two comments should be made regarding additional regulation of the shoreline. First, significant degradation of the State's beaches has been identified. This problem will not go away, and in fact, is expected to accelerate. Before judgment is rendered on the proposals in this report, the reader should be aware of the extent of the erosion problem, the impact on the State's shoreline and projections for future change, assuming no action is taken. Second, it may be possible to coordinate the regulatory process so that even with the addition of new regulatory controls, there will be fewer regulatory hurdles. In this report, there is a discussion on coordination of the regulatory process.

### A. Beach Degradation on Oahu

Analyses of the earliest air photos for Oahu indicate that between 1928 and

1980, beach resources have been steadily lost from hardening of the shoreline (Hwang, 1981). Along the windward coast highway near Kualoa for example, the beach disappeared during the 1928 to 1978 period due to the combined effects of a series of groins and vertical seawalls. Between 1949 and 1975, wave reflection off a vertical wall contributed to the loss of beach at Swanzy Beach Park. Over the same 26-year period, Laniloa Beach was degraded by the steady erosion of the shoreline and the stabilization of the backshore with boulder piles and revetment. Between 1949 and 1980, the beach at Bellows, located at the north end of the Waimanalo littoral cell, has narrowed or disappeared in front of a sloping stone revetment. In Hwang (1981), it was noted that seawalls, revetments and boulder piles had caused the total length of recreational beaches on the island to steadily decline over the 1949 to 1980 period. The latest date of aerial photographic coverage for the 1981 study varied with each beach, but was generally from 1975 to 1980.

In the last twelve to seventeen years, the pace of beach loss and degradation has not only continued, it appears to have accelerated. Since the 1975 to 1980 period, over two miles of combined beach have been lost at Iroquois Point, and Kahala on the south shore; and at Lanikai, Punaluu, and Mahie Point on the windward coast (Fig. 1). These recent changes are described in the following paragraphs.

1. Iroquois Point - (Fig. 2). Between 1928 and 1967 the vegetation line at Iroquois Point receded by as much as 140 feet. Over a similar period the water line receded by about 150 feet. Although there has been chronic erosion and significant inland migration of the shoreline, the 1967 aerial photograph documents a wide beach. The 1967 photo of Iroquois Point illustrates the general rule that a beach migrating inland in its natural state doesn't wash away but simply shifts position. The beach width remains relatively constant if there is no vertical inland barrier.

During the 1967 to 1990 period, continued migration of the shoreline threatened to undermine several houses. The 1990 aerial photo shows that after the shoreline was stabilized with bulkheads and stone revetments, the beach was lost along an 800 foot stretch.

2. Kahala - (Fig. 3). Over the 1949 to 1988 period, the vegetation line and water line at the southwest end of Kahala was relatively stable, in part due to the

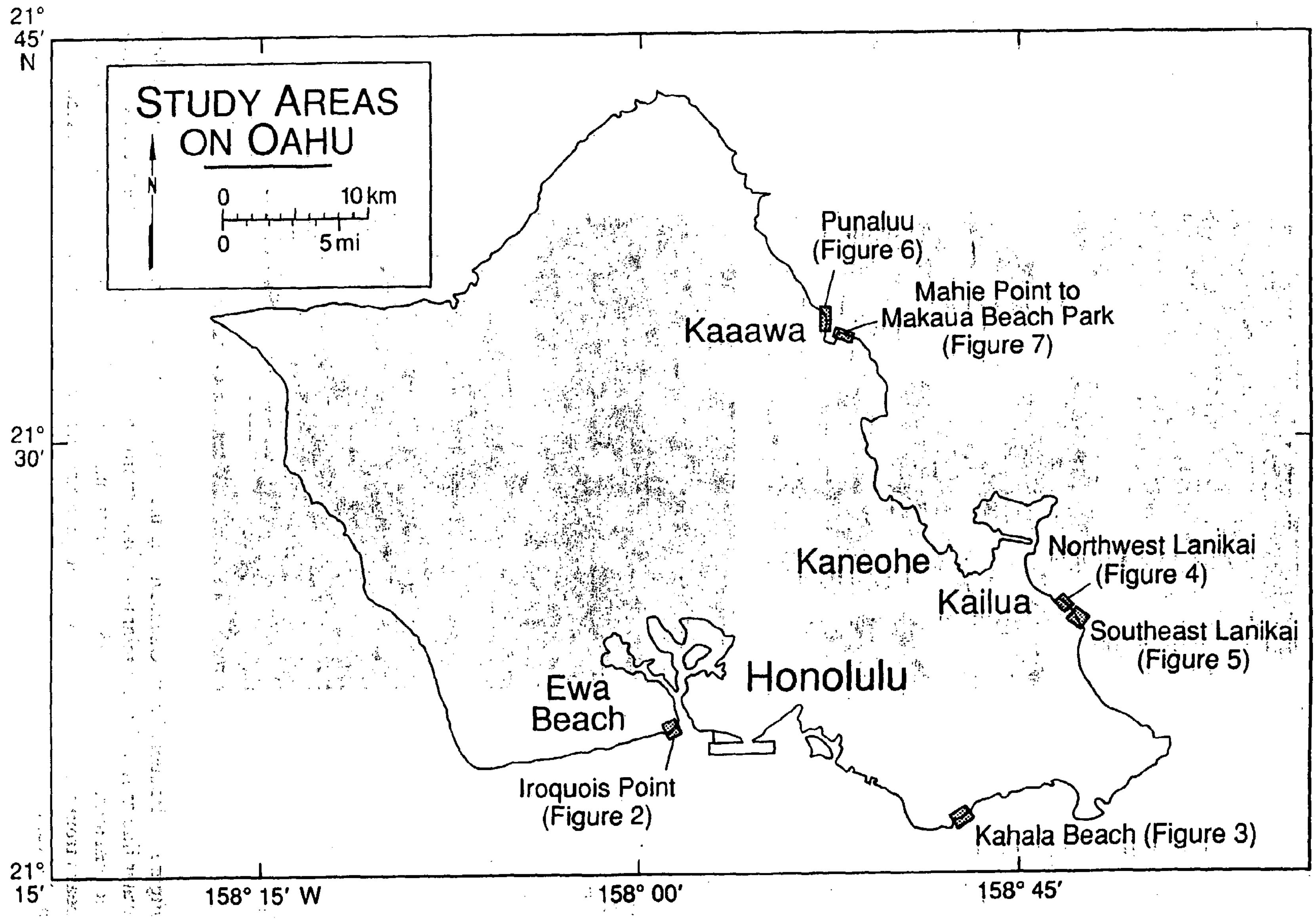
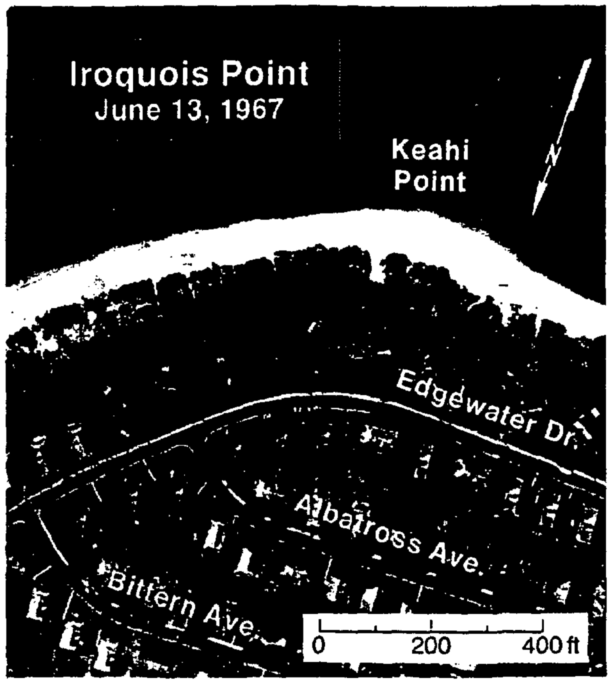



Figure 1. Map of Oahu Showing Figure Locations.



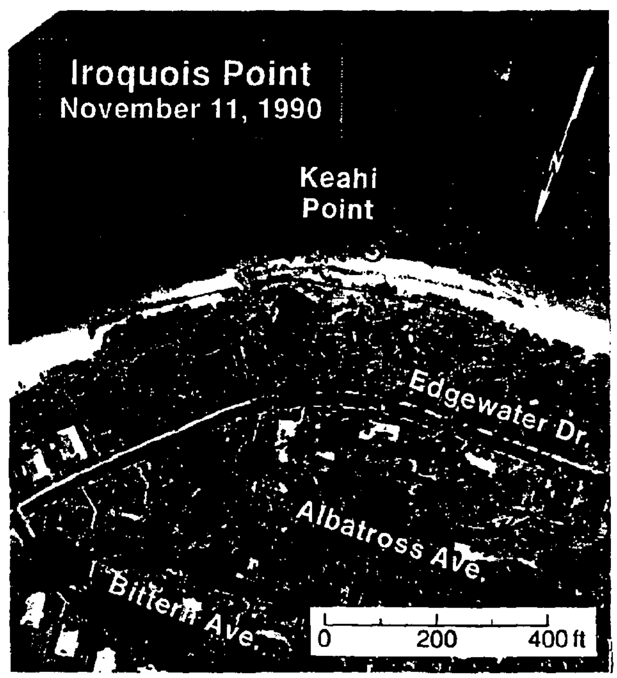
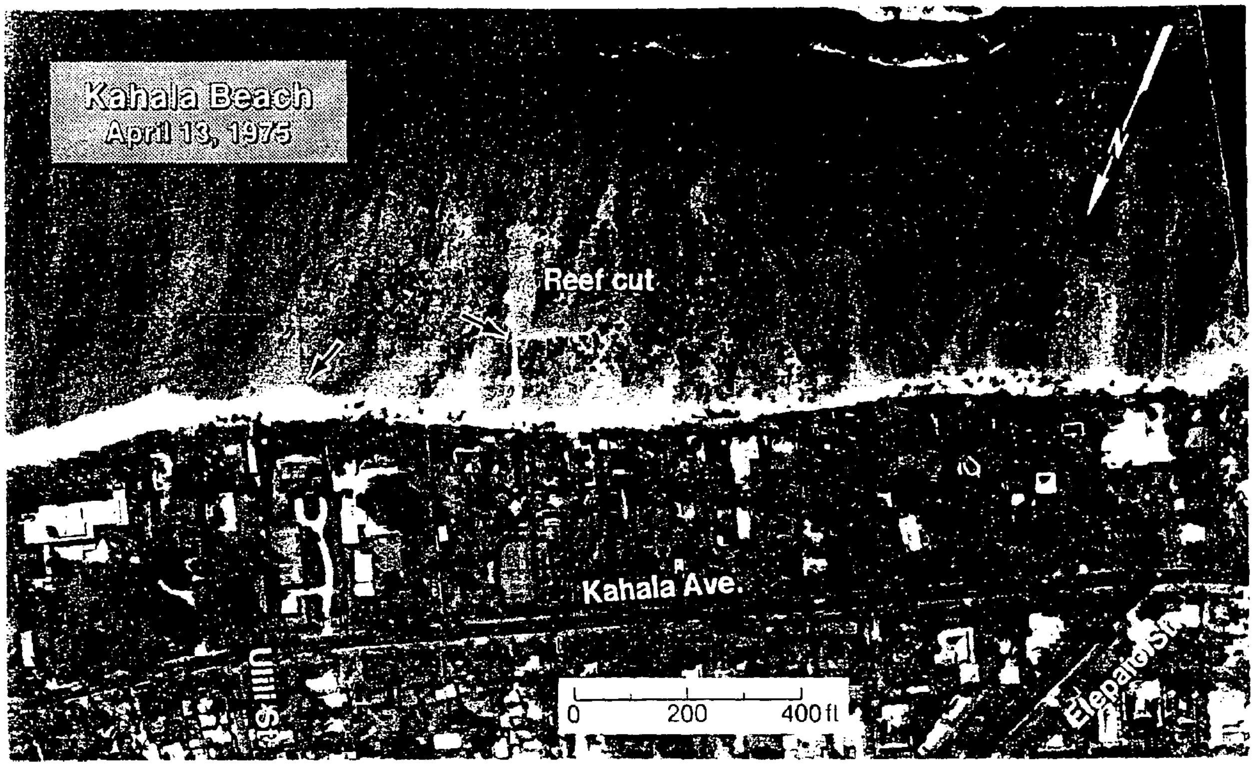




Figure 2. Iroquois Point, Oahu. During the 39 year period prior to 1967, the vegetation line and water line at Keahi Point migrated inland approximately 140 feet. Despite the chronic erosion, the unstabilized beach in 1967 had recreational value. The 1990 photo shows the impact on the beach from continued inland migration and stabilization of the shoreline with bulkheads, seawalls and revetments.



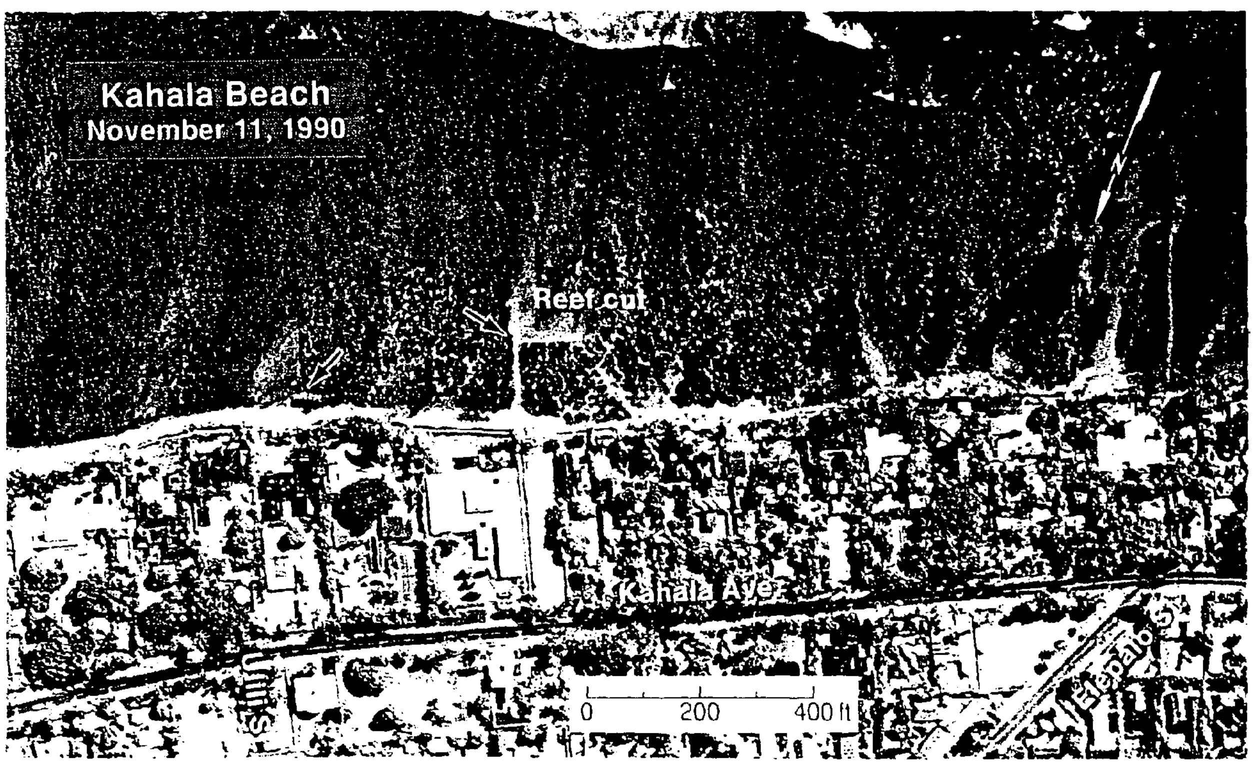




Figure 3 Kahala Beach, Oahu The west end of Kahala Beach has been characterized by relative stability Nevertheless, minor fluctuations in the position of the shoreline caused homeowners to harden the coast By 1990, much of the narrow beach at Kahala was lost to seawalls and revetments

dissipation of wave energy by a shallow fringing reef approximately 500 to 1,000 feet offshore (Sea Engineering Inc., 1988). In addition, Black Point may block some wave energy from the west-southwest. Although the shoreline at Kahala is relatively stable, the homeowners have hardened the shoreline with seawalls and revetments. A comparison of the 1975 and 1990 aerial photos reveals that a narrow beach was lost along 2,200 feet of the Kahala shoreline.

It is important to differentiate between the examples at Kahala and Iroquois Point. While Iroquois Point has experienced chronic erosion, Kahala Beach has been relatively stable. Nevertheless, beaches were lost at both sites. The Kahala example demonstrates that even beaches that have been relatively stable for a long period can disappear once seawalls or revetments exert sufficient influence on nearshore sediment transportation. In fact, most of the beaches on Oahu that have been lost or impacted by hardening of the shoreline do not have a long-term history of chronic erosion.

<u>3. Northwest Lanikai</u> - (Fig. 4). From 1950 to 1975, the vegetation line at northwest Lanikai experienced minor fluctuations in position of about 15 feet. The 1975 photo indicates that these fluctuations were insufficient to spur homeowners to construct seawalls or revetments. Beginning in the late 1970's and early 1980's, however, erosion along a 1,500 stretch threatened several houses and resulted in the construction of seawalls and revetments. The 1990 aerial photograph shows the impact on the beach from these hardened structures. Although there is a narrow beach fronting the seawalls on the 1990 photograph, field visits indicate there are numerous times of the year where the beach is entirely lost. Studies indicate that wave reflection off the seawalls or revetments may inhibit sand deposition on this coast. (Sea Engineering, Inc., 1988, Edward K. Noda & Assoc., 1989).

<u>4. Southeast Lanikai</u> - (Fig. 5). Between 1961 and 1971 the vegetation line at the southeast end of Lanikai advanced seaward by as much as 139 feet. Some of the accretion was lost during the 1971 to 1975 period. On the 1975 aerial photograph, there is a wide beach at the south end of Lanikai. Between 1975 and 1988, the vegetation line receded by as much as 84 feet (Sea Engineering, Inc., 1988). The 1990 aerial photograph shows that what was once a wide recreational beach in 1975 has been lost along a 1,800 to 2,000 foot span of seawalls and revetments. Numerous field checks to southeast Lanikai indicate that the beach loss along this sector is more persistent than at the northwest end of Lanikai.

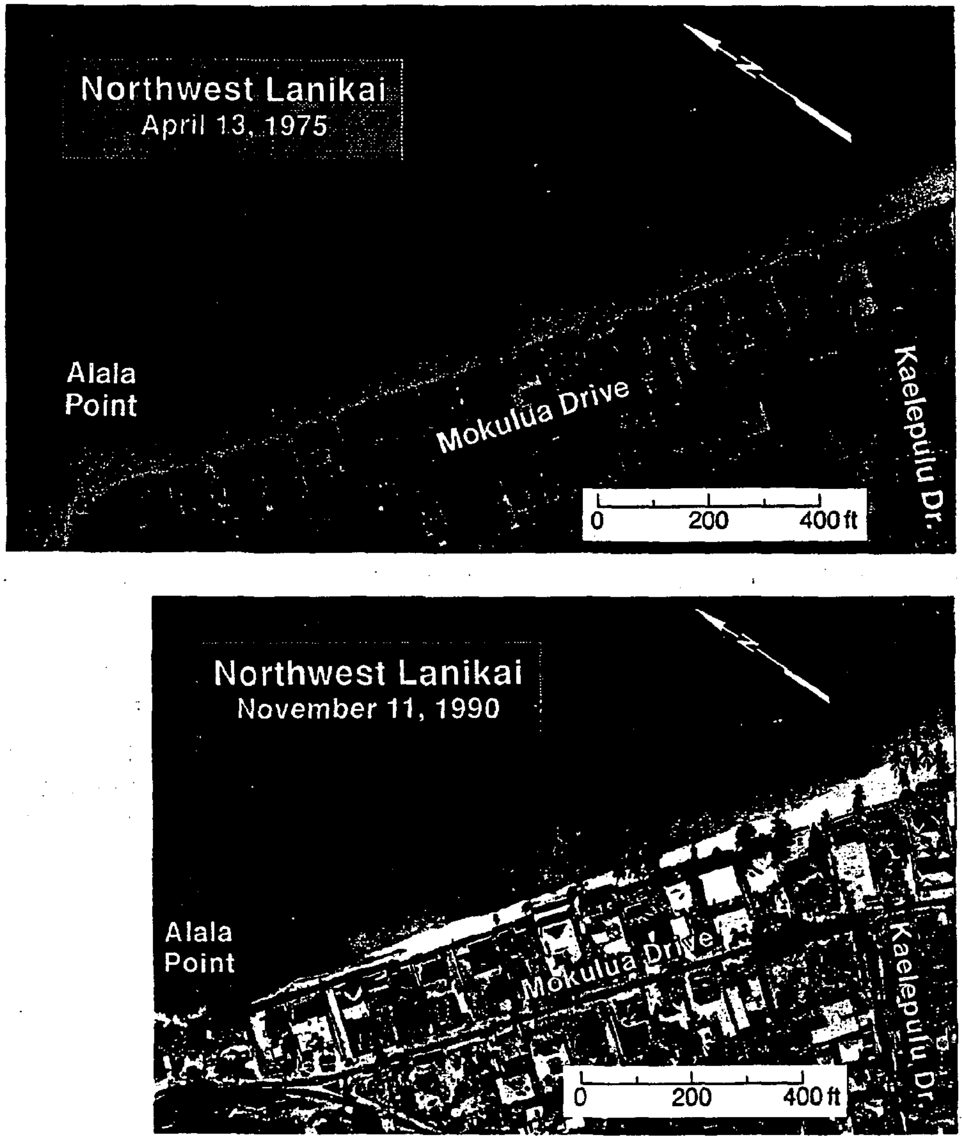



Figure 4. Northwest Lanikai, Oahu. Prior to 1975 the beach at Lanikai had a history of minor, alternating erosion and accretion. During the late 1970's and early 1980's, pronounced erosion spurred homeowners to stabilize the shoreline. The 1990 aerial photograph shows seawalls and revetments along the shore, a narrowed beach, and the exposure of beach rock towards Alala Point.

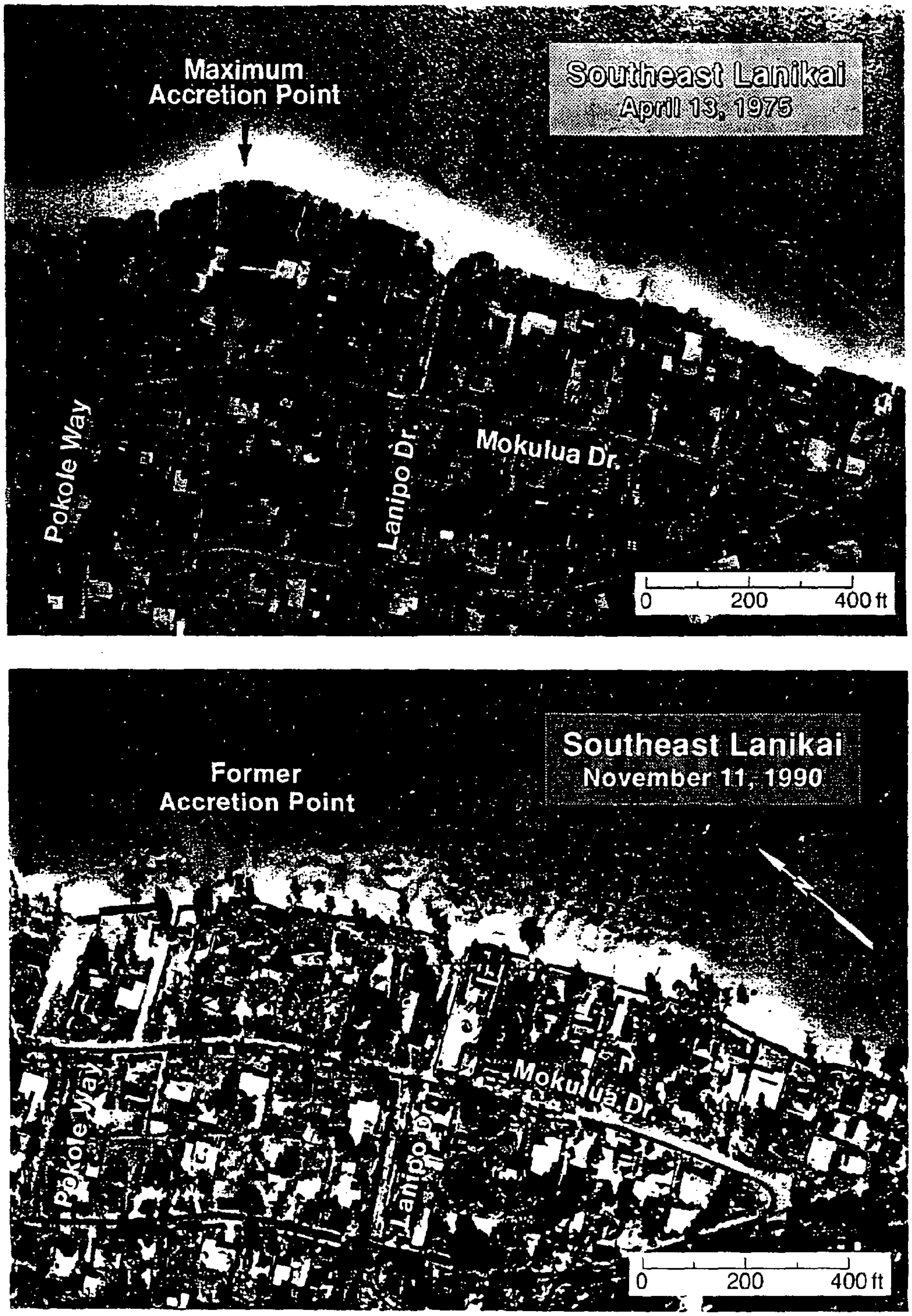



Figure 5. Southeast Lanikai, Oahu. Prior to 1971 most of the southeast end of Lanikai experienced accretion. The accretion trend was reversed in the 1970's. Hardening of the shoreline in response to severe erosion has led to the disappearance of the recreational beach The 1990 photo was taken late in the day, and shadows from trees are in the water.

5. Punaluu - (Fig. 6). The residential section to the northwest of Makalii Point has been either stable or accreting during the period from 1949 to 1975. In some sectors the vegetation line advanced seaward 63 feet (Hwang, 1981). Between 1975 and 1988 the accretionary trend reversed and much of Punaluu receded by as much as 58 feet (Sea Engineering, Inc., 1988). The 1990 aerial photograph shows that approximately 1,200 feet of sandy shoreline has been lost to the northwest of Makalii Point along a uniformly constructed revetment. The losses at Punaluu demonstrate that even if adjacent property owners cooperate to stabilize the shoreline with well constructed, uniform structures that have consistent alignment, the beach may still be lost. To the far south of Makalii Point the beach has narrowed or has been lost along a 1,600 foot stretch. Some of the negative impacts along this stretch occurred before 1975.

6. Mahie Point to Makaua Beach Park - (Fig. 7). It is along the windward coast where the most extensive shoreline degradation has occurred. The reach from Mahie Point to Makaua Beach Park is a typical example of the impacts. The beach as shown on the 1975 aerial photograph has narrowed, and in many places disappeared by 1990 along a 2,500 foot stretch of armored shoreline.

## Summary

A preliminary estimate, or reconnaissance, was made on the island of Oahu to determine the length of beaches that have been lost or degraded. In this report, beach loss and beach degradation are grouped into one category. In many instances, it is not possible to differentiate between the two since there is a continuum between the conditions. True beach loss would be the presence of no beach seaward of an erosion control structure during mean lower low water for all seasons of the year. While many shoreline sectors are believed to fit within these parameters (e.g., portions of southeast Lanikai), it was beyond the scope of this report to confirm these conditions. Beach degradation is defined as the condition where the beach has narrowed sufficiently so that some time during the year, recreational use is denied or access along the shore is blocked (e.g., sections of Mokuleia Beach on the north shore during the winter, or sections of Laniloa Beach on the windward coast).

For Oahu, the length of coast where the beach was lost or recreational use was degraded was estimated from the following sources of information:

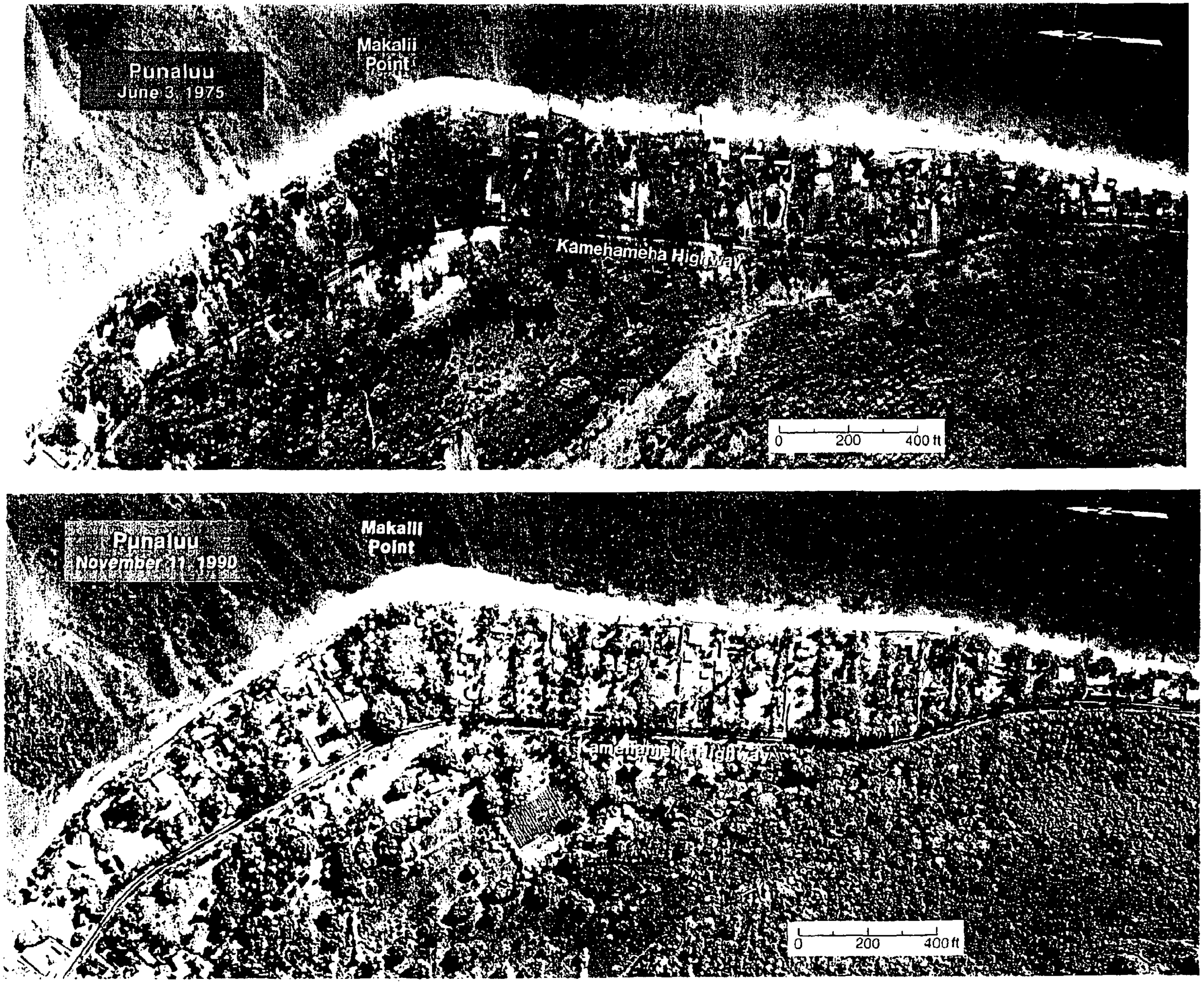



Figure 6 Punaluu Beach, Oahu. Prior to 1975 much of the shoreline to the extreme northwest of Makalii Point experienced accretion. Subsequent erosion and stabilization of the shoreline with a uniform alignment of revetments has led to disappearance of the beach.

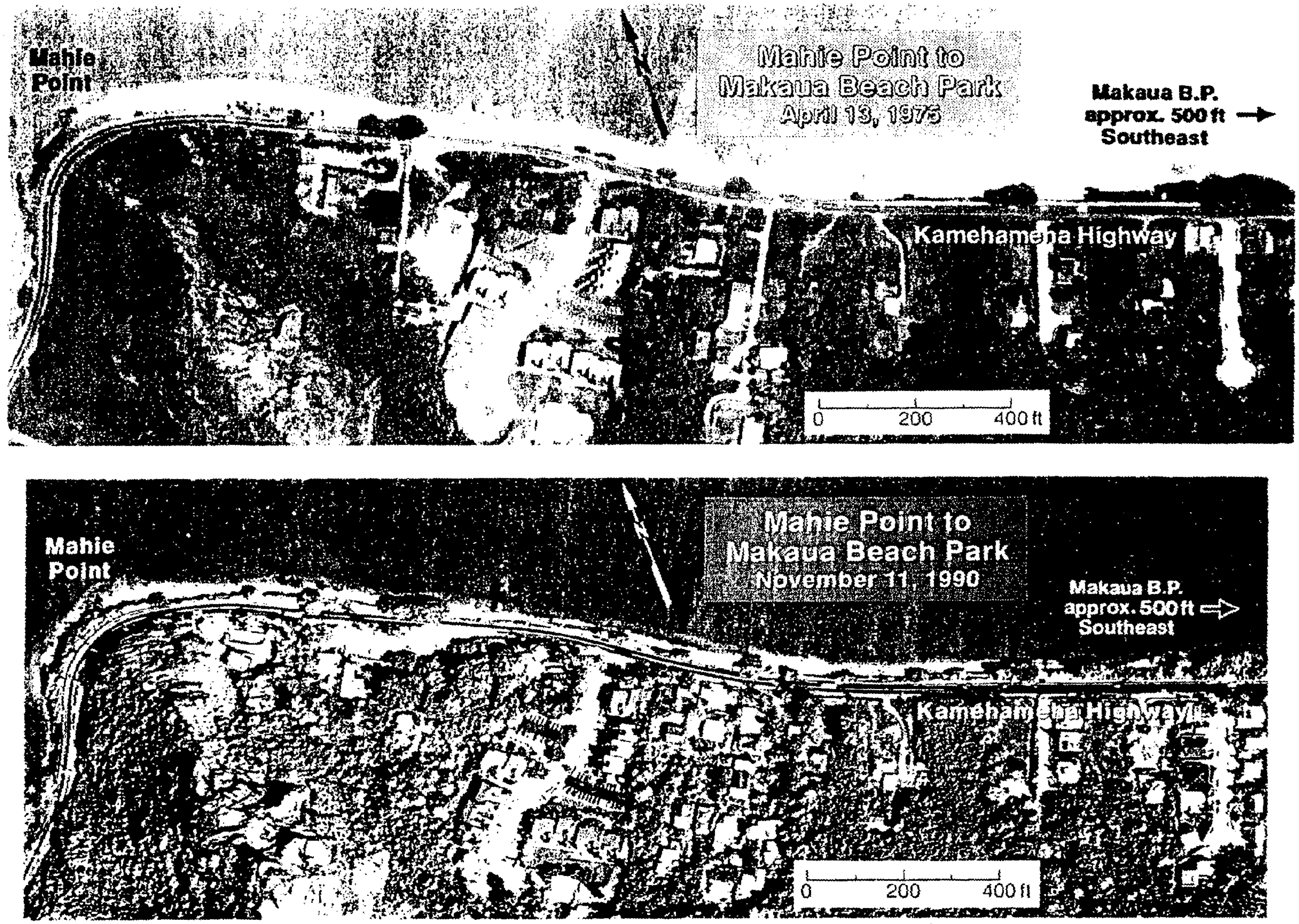



Figure 7. Mahie Point to Makaua Beach Park, Oahu. Significant beach degradation has occurred along the windward coast. These photos illustrate the beach degradation along a hardened shoreline in front of the Kamehameha highway.

1) Beach Changes on Oahu as Revealed by Aerial Photographs (Hwang, 1981).

2) Oahu Shoreline Study: Part 1 Data on Beach Changes (1988) (Sea Engineering Inc., 1989).

3) A set of aerial photographs taken of the Oahu coastline on November 11, 1990, by the R.M. Towill Company.

4) Field checks at specific locations that have been impacted.

A map of the island of Oahu (Fig. 8), shows the location of shorelines that have experienced degradation. It is estimated that 8 to 9 miles of beach on Oahu have either disappeared, or have narrowed to the point where recreational use is temporarily denied. The total length of beaches studied in the 1981 Oahu report was approximately 60 miles. Therefore, the length of coast that has experienced beach loss or degradation is almost 15% of the total length of beaches studied in the 1981 Oahu report.

The above figures, do not include the loss of beaches due to stabilization at Portlock, Waikiki or the west end of Diamond Head Road. In addition, the above figures should be viewed as a first estimate subject to later revision since it was beyond the scope of this report to field survey impacted shorelines.

Beach loss on the island of Oahu appears to have accelerated. Of the 8 to 9 miles of impacted beaches, approximately 4 to 4.5 miles of beach were severely impacted or almost lost. Half of the severely impacted shorelines disappeared between 1928 and 1975. The other half was lost between 1975 and 1990 (e.g., Punaluu, Mahie Point, Lanikai, Kahala, Iroquois Point).

**B. Beach Degradation On The Outer Islands**

The loss of beach resources is not confined to Oahu, but has occurred throughout the other islands. The reader is referred to the 1991 aerial photographic study for the islands of Kauai, Molokai, Lanai, Maui, and Hawaii (Makai Ocean Engineering, Inc. and Sea Engineering, Inc., 1991; hereafter MOESE, 1991). This valuable study clearly documents beach erosion and accretion trends by tracking historical movements of the vegetation line. More such documentation is needed,

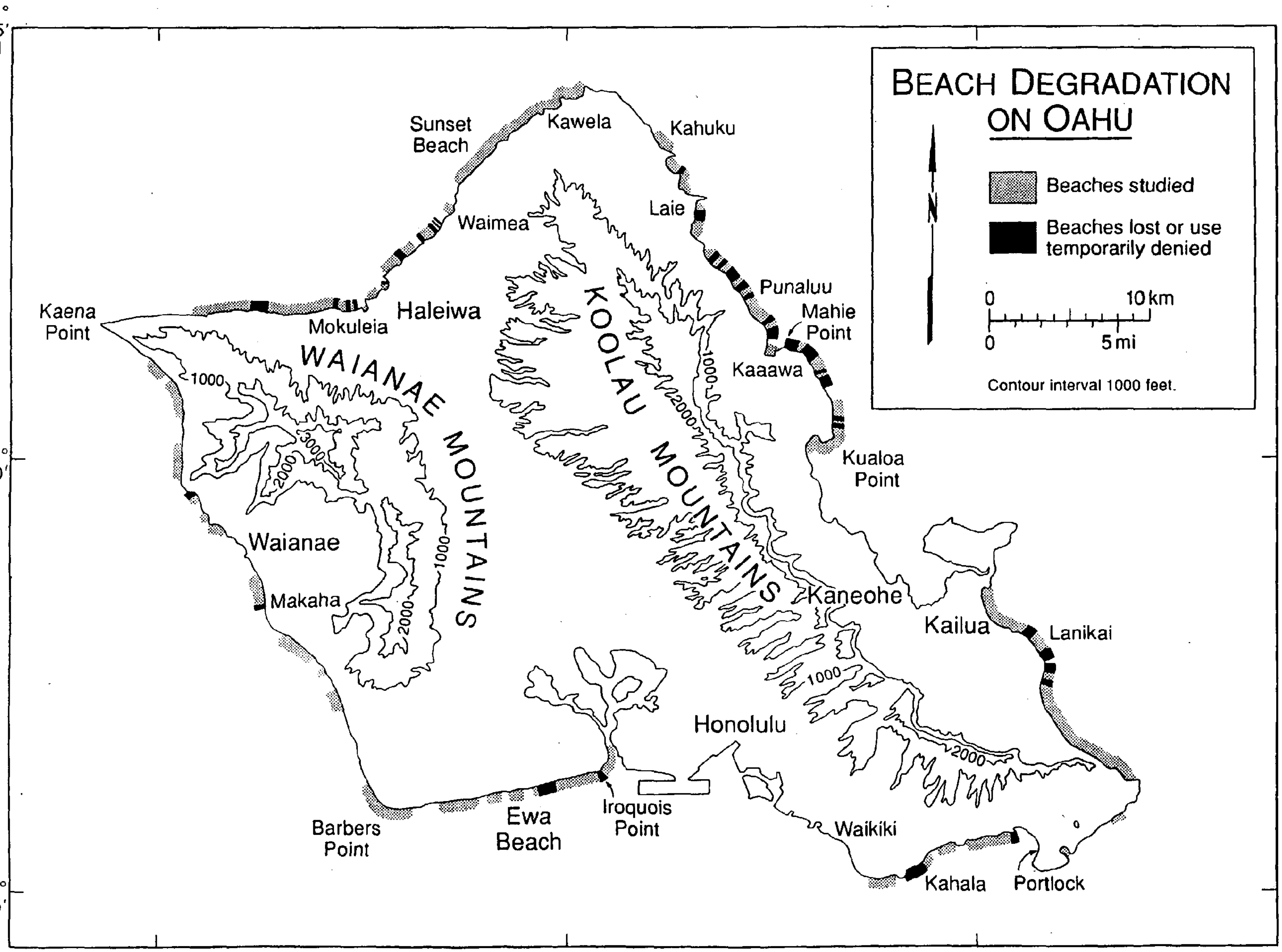



Figure 8. Beach Degradation on Oahu.

both to fill in the coastal segments not covered in MOESE (1991), and to establish continuous erosion and accretion trends rather than at selected transect locations.

A reconnaissance of selected beaches on the outer islands revealed that diminished recreational use, beach loss, beach narrowing, and preconditioning for future beach degradation are significant problems on Hawaii, Maui, and Kauai. These impacts are clearly associated with a wide-spread trend towards shoreline hardening. Due to the proliferation of stabilization structures in the backbeach area, and the continuing rise of sea level, beach loss and degradation is expected to accelerate in the future. Beach degradation will accelerate more rapidly if the present rate of sea-level rise remains constant. In the event of accelerated sea-level rise, as projected for the next several decades by numerous researchers, beach degradation in the State will accelerate to a critical level, threatening beach resources on a State-wide scale.

1. Hawaii - The island of Hawaii lacks the extensive system of beaches that characterize other islands in the State. This is because Hawaii is geologically younger, a condition typified by shear cliffs, poor reef development, and rapid subsidence of the island. Without the low-lying gentle coastal plains and the shallow offshore platform which are found on more mature islands, it has not been possible for extensive reef tracts to develop on parts of the island's coast. Since reefs and reef-dwelling organisms are the principal source of carbonate beach sand, there are fewer beaches on the Big Island. This condition makes beach degradation all the more critical.

With the exception of small pocket beaches located at river mouths, and where lava flows have been particulated to form black sand beaches, the North Kohala, Hamakua, and Puna Districts are characterized by a general lack of natural beaches. The few beach systems in these regions have never been analyzed for long-term erosion/accretion trends and no data exist to allow an assessment of the extent of degradation.

In the town of Hilo, the shoreline of Hilo Harbor is stabilized (Fig. 9). Due to the construction of a stone revetment to stop the erosion of water-front lands and as a deterrent to the tsunami hazard, as much as 1 mile of beach has been lost. A rapid relative sea-level rise on the Hilo coast of over 1.5 in/decade, has caused the volcanic sand beach to migrate quickly landward. When the rising water reached the revetment, beach migration ceased, and beach erosion accelerated to the point

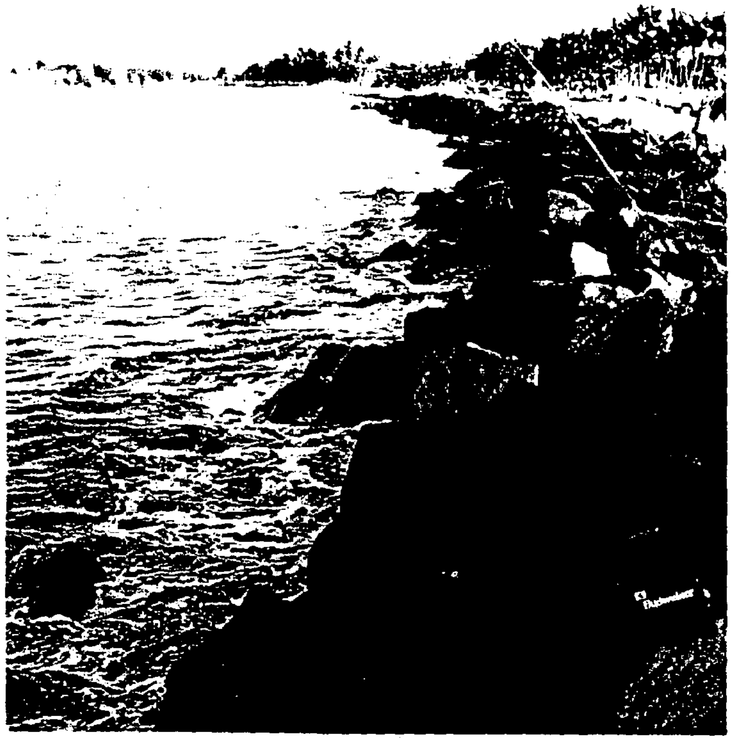


Figure 9. The stone revetment at Hilo Harbor, Hawaii. Here the relative sea-level rise exceeds 1.5 inches/decade. Hardening of this shoreline has forced the loss of the beach to protect the adjacent lands.

Figure 10. Kona Coast of Hawaii. This artificially steepened beach on the Kona coast of Hawaii enhances the tendency for sand to move offshore, accelerating erosion. The oversteepening of this beach increases wave energy on the beachface, accompanied by high velocity surging in the swash zone. Note the freshwater pond and the landscaped vegetation on the back of the beach

where today the water laps against the stone face of the wall.

On the leeward side of Hawaii, analysis of historical movements of the vegetation line on 29 beach transects in the South Kohala and North Kona Districts (MOESE, 1991) revealed that since about 1950, 17 sites (59%) are eroding. The average rate for the eroding sites is -0.6 ft/yr, and the average rate for the accreting or stable sites is 0.35 ft/yr. Rates of vegetation line movement were extrapolated to the year 2018 for these locations, and the probability for successful prediction, relative to a random occurrence, was calculated in each case. In several cases the standard deviation of the extrapolated vegetation line was high, indicating that the extrapolation has a low predictive capability. These are often situations where beach behavior is cyclic, or where sudden beach changes have occurred and may not represent long-term trends. As a group, the eroding sites average 18 ft of recession by the year 2018 and the accreting sites average about 11 ft (relative to 1988). The average trend of all sites studied is to erode at a rate of -0.2 ft/yr, and to recede an average 6 ft by the year 2018.

While these figures indicate a state of regional beach erosion for the South Kohala and North Kona District coasts, they do not reflect factors and processes at individual beaches. For instance, beaches associated with resorts along this coast are frequently artificially nourished, and the beachface is often artificially steepened (Fig. 10), a procedure known as "beach scraping". Beach scraping should be discouraged since a steeper beach tends to reflect, rather than dissipate, wave energy. Wave reflection enhances erosion by promoting the movement of sand away from the beach. The steeper beachface also increases the velocity of the backwash, and the general movement of sand towards the foot of the steep slope. In addition to beach scraping, the area behind the active beach is often landscaped and maintained so that the vegetation line no longer reflects natural processes of beach change. In the future, our understanding of the beach will have to rely on profile monitoring and field surveys in these areas. In areas that are landscaped, the vegetation line is no longer a valid indicator of erosion or accretion trends. In fact these errors are probably already incorporated to some extent in the MOESE (1991) report.

Finally, it was made clear in field visits to Hawaiian beaches that many are preconditioned for degradation and eventual beach loss because of the presence of protective structures immediately landward of the sandy beach. Although this factor is not as prevalent on Hawaii as on Maui or Oahu, preconditioning was observed at several resort beaches. Considering the high relative rate of sea-level rise on Hawaii, if these beaches are not nourished or otherwise maintained on a regular schedule, or if existing stabilization structures are not removed, they will eventually be lost as the waterline migrates toward the armored upland.

2. Maui - On Maui, beach degradation in many locations has reached a critical stage because of the rapid relative sea-level rise there (nearly 1 in/decade) and the proliferation of shoreline stabilization structures (Fig. 11). In the MOESE 1991 report, 63 of 102 transects analyzed (62%) were found to be eroding, 25 (24.5%) were accreting, and the remainder had been stabilized by some form of armoring. In nearly all cases seawall or revetment construction followed a period of significant beach erosion, and resulted in beach loss. Together, erosion and hardening characterized over 75% of the studied shoreline. The eroding sites averaged -1.25 ft/yr, and the accreting sites averaged 1.08 ft/yr. Projections to the year 2018 suggest that the eroding sites will recede an average 36.4 ft, and the accreting sites will average nearly 24 ft (relative to 1988). The average trend of all nonstabilized sites is to erode at a rate of -0.6 ft/yr, and to recede an average of 18.8 ft. by 2018.

Maui is notable for the extensive beach loss, beach narrowing, and widespread use of stabilization structures, especially along the west Maalaea Bay coast and the reach from North Kihei to South Kamaole (Fig. 12). Other problem areas include portions of the Kahului coast and much of the shoreline between Lahaina and Kapalua. The tendency to stabilize receding shorelines on Maui has led not only to existing degradation, but also to the preconditioning of much of the coast to accelerated beach loss in the future. A number of fine wide beaches abut revetments and seawalls that are often fully vegetated. These structures were originally placed out of the reach of fairweather wave runup. With continued sea-level rise they will soon begin to reflect the incident wave energy leading to offshore directed sand transport, beach erosion, and eventual beach loss. Field visits identified a number of protective structures whose vegetative cover has recently been damaged by wave action. At these sites, the process of beach degradation has already begun. These locations show evidence of beach narrowing, deep beach cusp development and channeling, and accelerated erosion.

Ironically, there are a number of sites on Maui where beach loss has occurred on stabilized shorelines that are not protecting any upland development. For instance Kalama "Beach" Park is protected by over 3000 ft. of stone revetment

Figure 11. West Maalaea Bay, Maui. The west Maalaea Bay shoreline, Maui, formerly a calcareous sand beach. Erosion followed the construction of the Maalaea Bay Harbor jetty in 1952 (beyond the photo), and now 2400 ft of coast is hardened with revetments and seawalls.

Figure 12. A vegetated revetment on the highway near Kihei, Maui. Notice the deep indentation in the coast from a lack of sand due to the groin just to the north. This small beach is one of many that are preconditioned for loss. A vegetated revetment protects the highway. Although the beach exhibits signs of accelerated erosion, the revetment has stabilized the vegetation line and future aerial photographic analysis will not record the degradation. This beach will be lost when waves begin to interact with the revetment on a regular basis. This may occur following the next large storm, or as continued sea-level rise drives the waterline inland

that has led to the total loss of the beach (Fig. 13). Yet in places, the nearest upland development is almost 1,000 ft away from the revetment. The erosion at Kalama has produced accelerated beach loss downdrift (north) of the revetment on neighboring Waimahaihai Beach (Fig. 14), where a number of seawalls are erected on private properties. On unstabilized properties, 3 ft high erosional scarps mark the recession of the shore resulting from the loss of the area's sand supply. These will undoubtedly be the next sites for stabilization as the erosion proceeds landward and houses become threatened. As seawalls and revetments of various types spring up along this residential beach, the zone of enhanced erosion will be pushed along to the north. In fact, this is a "domino effect" resulting from the Kalama revetment, and exacerbated by the high rate of relative sea-level rise, which has the potential to cause a migrating beach loss problem reaching north along the entire Kihei coast.

Taken to the limit, a long stretch of stabilized and beachless coast can result in the complete termination of the sand supply. For instance, on the northwest coast of Maui at Honokowai (north of Lahaina), there is over a mile of stabilized shoreline that has no beach (Fig. 15). Immediately to the north of this section is Honokowai Beach Park, which is not stabilized, but is experiencing enhanced erosion. It is apparent that the extensive hardening of the coast to the south has prevented sand deposition at the beach park because the former sand source has been replaced by a line of seawalls. Without the longshore delivery of sand, the beach at Honokowai has no natural replenishment mechanism and over time it has eroded away. Today, the shoreline at Honokowai Beach Park is the location of coral rubble, cinder blocks, dirt, and a 2 ft erosional scarp marking the recession of the coast.

It is interesting to note that in the case of Kalama Park, the action of Maui county led to downdrift impacts on private property. In the case of Honokowai, the action of private landowners led to impacts on Maui county park land.

Perhaps most telling is the case of shoreline stabilization along the Honoapiilani Highway in the area of Punahoa beach, south of Lahaina. There, beach recession threatens to undermine the highway. To protect the highway, a crude set of concrete barriers (the type used as highway lane dividers), and an expensive revetment have been installed to stop the recession (Fig. 16). A formerly wide and healthy beach has been lost in the process. There is no development along this shoreline, only the two lane highway is threatened by the erosion.

Figure 13. Kalama Beach Park, Maui. Kalama Beach Park has had a long history of erosion. Here a 3000 ft sloping stone revetment designed to encourage sand accretion was built in the early 1970's. Today the former beach is gone, and the park is protected from further erosion.

Figure 14. Waimahaihai Beach, Maui. Waimahaihai Beach is immediately north of Kalama Park. Erosion caused by the Kalama revetment has led to the construction of 2400 ft of seawalls and revetments protecting private residences. Severe erosion characterizes the coast north of these structures. More than 1 mile of continuous sandy beach has been lost here in the last 15 years

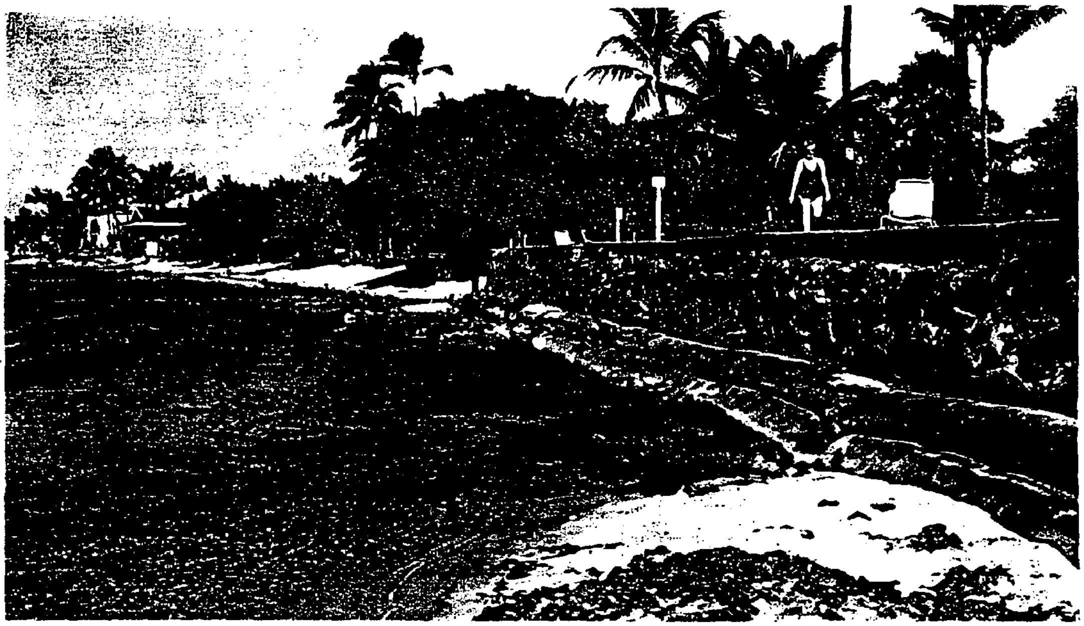


Figure 15. Honokowai Beach Park, north of Lahaina, Maui. Vertical seawalls extend along most of the 6,000 ft of coast downdrift (south) of this park. An erosion problem in the 1970's lead to the construction of the seawalls to prevent the damage or loss of beach front condominiums and resort hotels. Development of the shoreline occurred during a phase of temporary accretion, most buildings were placed 40 ft from the vegetation line at the time of construction. With the onset of sustained erosion, the setback proved inadequate. Now over 2 miles of former sandy beach is lost because of shoreline hardening on this coast and immediately to the north.

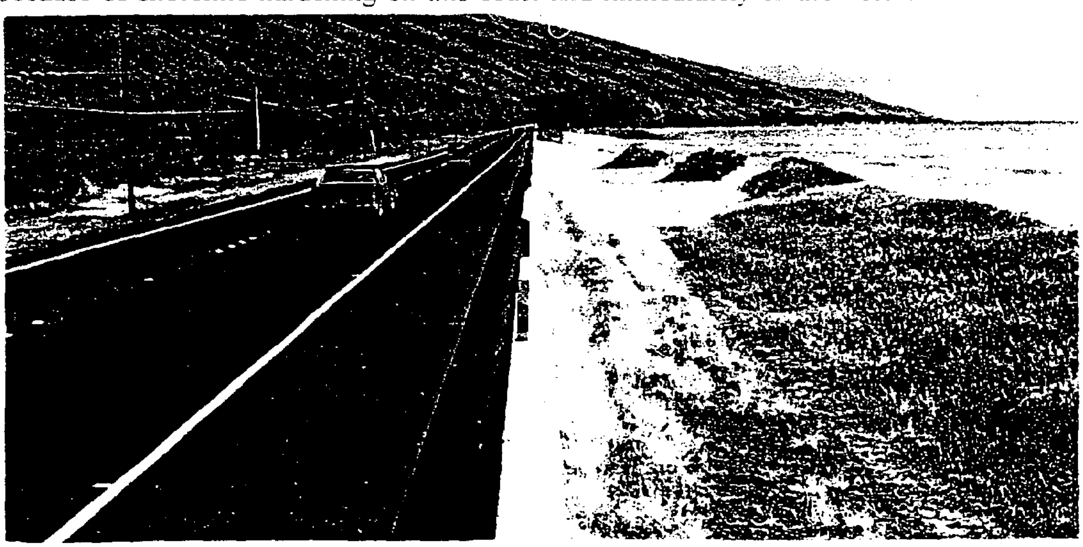


Figure 16. Punahoa Beach South of Lahaina, Maui. Severe erosion threatens the highway, now protected with combined temporary and permanent structures. Continued sea-level rise will lead to more permanent structures and eventual beach loss here. Instead the highway could be relocated.

Mauka of the road is a flat coastal terrace perhaps a mile wide. Rather than move the highway to the foot of the hills at the back of the terrace and make a beach park where the shoreline is receding, the beach is being sacrificed in the interest of protecting the highway. The crude barriers presently protecting the road will soon be inadequate and need to be replaced by a larger and longer stone revetment, at a cost of millions, perhaps tens of millions of dollars. Sand delivery to neighboring beaches will diminish and erosion will accelerate to the north of the site. Neighboring beaches will be impacted, and the structure will have to be extended to protect the road there. Very soon the size and cost of the protection will vastly exceed the cost to protect the road. Early planning could instead have created a beach park that would have relieved the crowding at parks near Lahaina and along Maalaea Bay, provided visitors and inhabitants with an additional recreational resource, preserved the State conservation land that is the beach, and saved enormous public funds.

3. Kauai - On Kauai, the MOESE (1991) report identified extensive stabilization and erosion along certain sites on the south and east coasts of the island. In the area from Hanamaulu to Kealia (makai of Lihue, on Kauai's east coast), 25 of the 42 sites studied (60%) are either stabilized or eroding. The average rate of erosion is -0.61 ft/yr, and at these sites the coast is projected to retreat an average of 19 ft by 2018. Other sections of the Kauai coast not covered in the MOESE report are also eroding, but many are not. The generally undeveloped nature of the north and west coasts show net accretion trends over the period studied, and erosion is usually confined to dynamic river mouth movement or natural fluctuations in the coastal sand budget. In every case where erosion is occurring without the influence of upland development or beach stabilization, the beach has maintained its width and sand supply even while retreating landward.

There are a number of erosion management problems on Kauai. At Kikiaola Harbor (Fig. 17) on the south coast, a massive jetty has interrupted the natural littoral drift causing an erosional offset in the coast a mile long and 100 ft wide. The jetty is being flanked by this erosion, and temporary extensions have been emplaced to keep the jetty attached to the shore. A cemetery is threatened by the erosion. The dune protecting it is on the verge of being breached by erosion which is occurring at over 2 ft/yr. Despite the massive erosion here, the beach is still wide and sand-rich, offering excellent recreational opportunities because the shoreline is not stabilized. If this segment is hardened, more than 1 mile of beach will be lost.

Figure 17. Kikiaola Harbor, Kauai. The erosional offset at Kikiaola Harbor, Kauai. Here, jetties used in the construction of the harbor, have interrupted the longshore pattern of sand movement and this downdrift offset in the coast has developed. The erosion rate exceeds 2 ft/yr; note the slumped and fallen trees and the eroded dune face, yet because the shoreline is not stabilized the beach is still wide and has recreational value despite the high erosion rate.

Figure 18. The Residential Beach at Waipoli, Kauai. Jetties both north and south of this segment block the longshore sand supply in the winter and summer, respectively. As a result the shoreline erodes at 1.5 ft/yr. Previous erosion rates were higher (4.3 ft/yr) but the beach is mostly gone now and a earthen scarp is eroding into the residential frontage road. This stretch is likely to be hardened soon, preventing any possibility of beach recovery

At Waipoli Beach (Fig. 18), north of Lihue, severe erosion has led residents to construct rubble mounds and to dump boulders as temporary barriers in order to protect the small frontage road which is the only access they have to their homes. A 5 ft erosional scarp threatens to undercut the road. Roots are exposed and trees are ready to fall as the scarp continues to develop. The beach is gone, and beach rock tends to channelize water at the base of the scarp exacerbating the erosion. Immediately to the north and south are stone jetties extending 100 to 300 ft offshore. These interrupt the seasonal littoral sand drift which would otherwise nourish this former beach. Large waves in the winter months generally come from the north, hitting the coast at an angle and driving a longshore current that transports sand to beaches in the south. The jetties at the mouth of the Waikaea Canal prevent this sand from reaching the residential beach at Waipoli. In the summer months, large waves come from the south, and drive a littoral drift of sand that is interrupted by jetties stabilizing a small drainage canal to the south of Waipoli Beach. Although the seasonal littoral sand supply to Waipoli residential beach is blocked by these jetties, the wave energy is not. As a result, winter waves from the north take sand away from the site and transport it to the south, and summer waves from the south transport the little remaining sand to the north. Broad pockets of accumulated sand immediately inside the neighboring jetties testify to this process. The residential coast is serving as an unreplenished source of sand to the areas north and south. Eventual stabilization of this coast will prevent the potential return of the beach should one of the jetties be removed.

Other problems can be found as well. At Kapaa Beach Park, reef dredging has created a deep hole offshore that traps all sand otherwise destined for the beach. Along the park shoreline the beach has been lost, and large ironwood trees are being undercut by an erosional scarp. At the Wailua Golf Course, a 3500 ft stone revetment has been built to protect the fairway and several greens. The beach in front of the structure has narrowed considerably in the 5 years since protection was established and what was formerly a 3/4 mile-long, wide and dynamic beach is now degraded, and will soon disappear. The impacted littoral drift is likely to lead to chronic erosion problems both north and south of the golf course where no erosion problem presently exists.

These are typical examples of beach degradation that are found on Kauai, as well as on the other Hawaiian Islands. Many of these cases of beach degradation and loss could have been avoided by informed planning based on a knowledge of littoral processes, rates of relative sea-level rise, and the long-term implications of shoreline stabilization under rising sea level.

## C. Global and Local Sea-Level Rise

1. <u>Global Sea Level</u>. Perhaps few scientific issues in recent decades have been so intensely examined on an international level as the predictions of global climatic warming and sea-level rise in the 21st century. These predictions are based on our understanding of atmospheric processes involving heat-trapping compounds ("greenhouse gases") that prevent the infrared radiation heat of the earth from escaping to space (called the "greenhouse effect"). Because of the build-up of these gases in our atmosphere, computer-based global circulation models have predicted climatic warming in the 21st century. The worrisome aspect of this prediction is its factual basis in the observed increase of carbon dioxide ($CO_2$, an important greenhouse gas) and other heat-trapping gases in the atmosphere (Fig. 19). However, scientists still have difficulty predicting: 1) what exact effect the increase of greenhouse gases may have on the global climate; 2) what effect global warming may have on localized temperature and humidity patterns; and 3) the exact magnitude of sea-level movements to be expected under a warming climate.

To date, the most reliable scientific consensus on potential global climate change in the next century is the assessment of the Intergovernmental Panel on Climate Change (IPCC, 1990). The IPCC report is the product of over 200 international climate researchers working under the auspices of the United Nations and the World Meteorological Organization. Among their findings is a prediction for accelerated sea-level rise through next century (Fig. 20). Their results agree with estimates of other researchers (NRC, 1987; NRC, 1990a, 1990b) and have generally been accepted by members of the research and policy-making community.

In the IPCC report (1990), global mean sea level is projected to rise at an average rate of about 2.36 in/decade (6 cm/decade) over the next century, with an uncertainty range of 1.18 to 3.94 in/decade (3 to 10 cm/decade). The projected rise is about 7.9 in (20 cm) by the year 2030, and 25.6 in (65 cm) by the end of the next century.

Several factors affect sea level on the global scale, but four major effects are attributed to global warming. These are, thermal expansion of ocean water, changes in the Greenland and Antarctic ice sheets, and melting of mountain glaciers. The best estimate of future sea-level trends in the IPCC model is

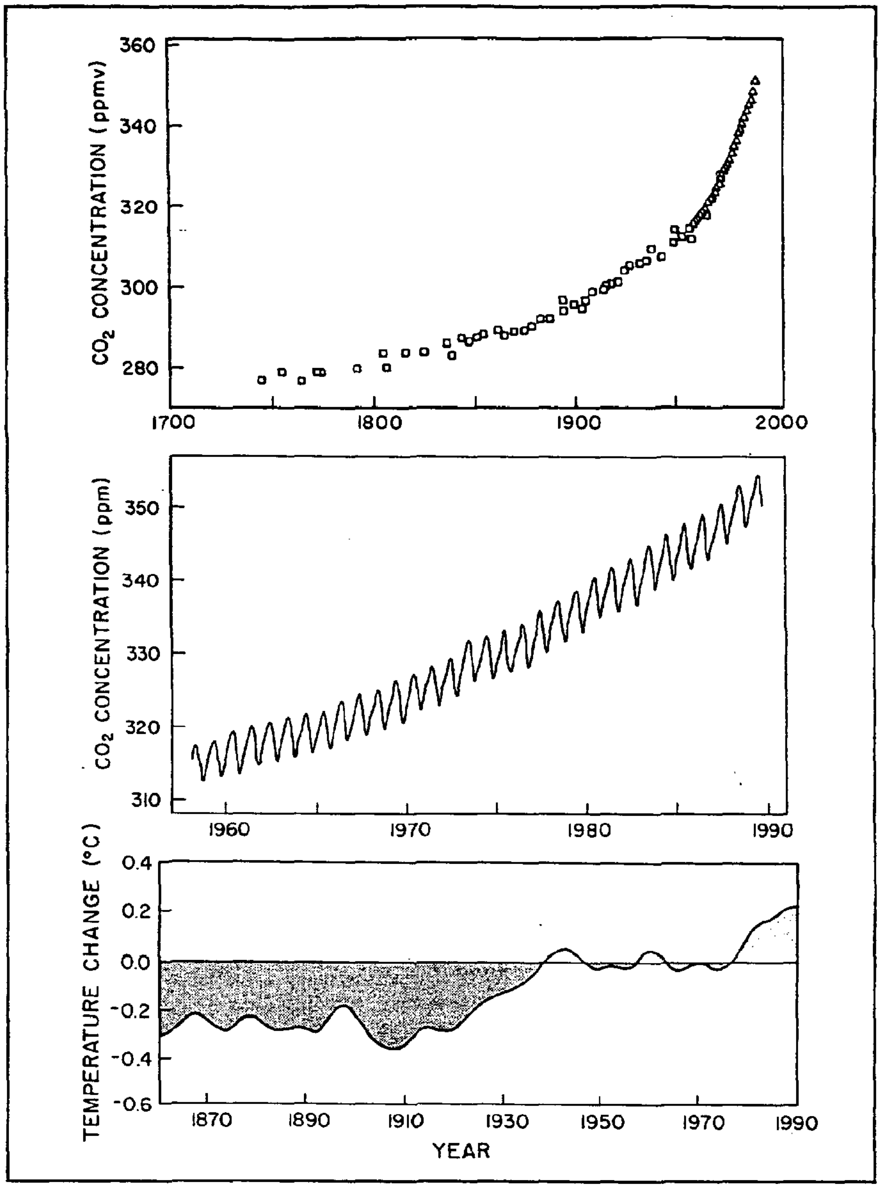



Figure 19. Intergovernmental Panel on Climate Change, 1990. The basis for predicting global warming in the 21[st] century. **Top:** Atmospheric carbon dioxide has risen since the start of the industrial revolution and the large-scale burning of fossil fuels. Global annual emissions of $CO_2$ by fossil fuel burning and other industrial activities have increased annually by about 4% since 1860. These data are $CO_2$ content (parts per million by volume) of air bubbles trapped in ice that was cored from the Antarctic ice sheet. **Middle:** Monthly average $CO_2$ concentration in parts per million of dry air observed continuously at Mauna Loa, Hawaii. The annual variations shown are produced by the seasonal production (winter) and withdrawal (spring and summer) of carbon dioxide by living organisms on land. **Bottom:** Global-mean combined land-air and sea-surface temperatures, 1861-1989, relative to the average for the period 1951-80. This record is controversial, but it shows a warming trend over the entire period, highlighted by pronounced warming since the late 1970's. The record is the best estimate of global temperature change over the last century or more. Is the warming real? Is it a natural climate fluctuation? Is it the product of $CO_2$ build-up in the atmosphere and an enhanced greenhouse effect?

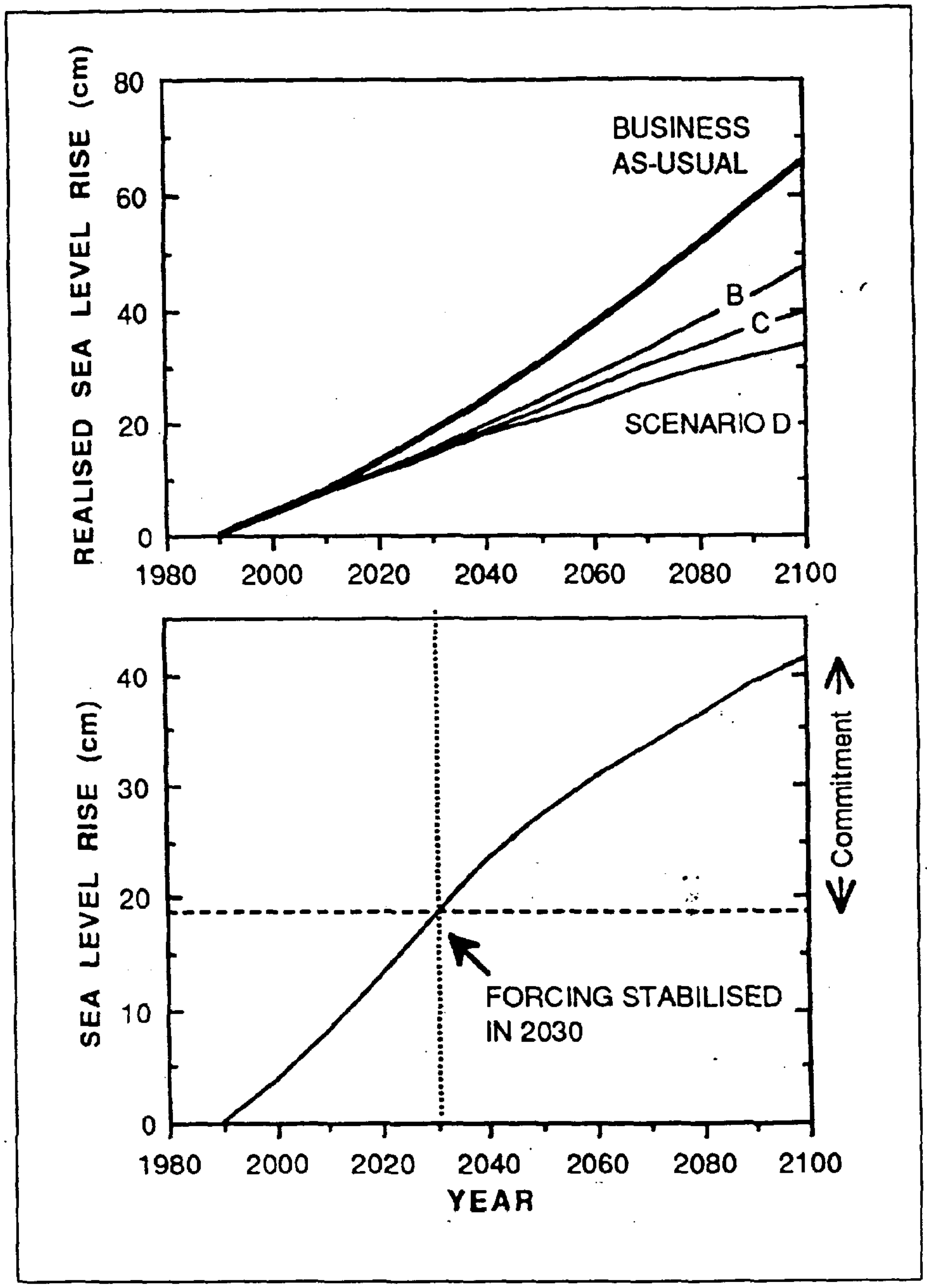



Figure 20. Projected Sea-Level Rise. **Top**: Sea-level rise projected by the IPCC (1990) between 1990 and 2100. The "business as usual" scenario is a model of sea level assuming uncurtailed industrial emissions of greenhouse gases, a scenario currently being fulfilled by the U.S. **Bottom**: According to calculations, even if production of greenhouse pollutants (greenhouse forcing) increased no farther, there would still be a commitment to continuing sea-level rise for many decades due to a delayed response of natural climate factors. If the increases in greenhouse gases were to stop in 2030, sea-level would go on rising to 2100, by as much again as from 1990 to 2030.

composed mainly of positive contributions from thermal expansion of oceanic surface waters, and melting of mountain glaciers. Future changes in the Greenland and Antarctic ice sheets are poorly understood and heavily debated by researchers.

In the IPCC report (1990), global mean sea level is projected to rise at an average rate of about 2.36 in/decade (6 cm/decade) over the next century, with an uncertainty range of 1.18 to 3.94 in/decade (3 to 10 cm/decade). The projected rise is about 7.9 in (20 cm) by the year 2030, and 25.6 in (65 cm) by the end of the next century.

Attempts have been made to quantify the various components of global sea-level change. The most widely accepted, published estimates include thermal expansion estimated as a positive effect on global sea-level movement (0.08 to 0.24 in/decade; Wigley and Raper, 1989), and melting of mountain glaciers and small ice caps estimated as a positive effect on global sea-level movement (0.08 to 0.28 in/decade; Meier, 1990). The nature of change in the Greenland ice sheet is debated. One interpretation of satellite data suggests the ice sheet is thickening and might be removing water from the oceans (Zwally, 1989). The Greenland ice sheet is, nonetheless, estimated as contributing to sea-level rise at 0.03 to 0.15 in/decade (IPCC, 1990). Changes in the Antarctic ice sheet, which is considered to be thickening, not melting, are thought to decrease the rate of global sea-level rise. The Antarctic contribution is estimated as -0.08 to -0.24 in/decade (IPCC, 1990). Two other factors that are not directly related to warming may affect global sea-level movement. The first, reservoir impoundment of surface water for human use, is estimated as a negative effect (-0.27 in/decade; Chao, 1991). The second, withdrawal of groundwater for human use and eventual discharge into the oceans, is estimated as a positive effect (0.03 in/decade; IPCC, 1990). The total net budget for sea-level change based on these components is 0.03+/-0.32 in/decade (-0.29 to 0.35 in/decade, Table 1).

It is instructive to compare a compilation of the supposed components of present global sea-level movement (-0.29 to 0.35 in/decade, Table 1) to global sea-level rise as actually recorded by tide gauges around the world (Table 2). As Table 2 shows, a number of researchers have statistically analyzed long records (>45 yr) of sea-level trends. Each estimate in Table 2 accounts for localized effects such as crustal subsidence, and compaction of sediments under the gauging station. These values (averaging 0.56+/-0.12 in/decade, Table 2) are measurements of actual present sea-level movement recorded by tide gauges around the world.

The range of values in Table 2 (0.4+/-0.04 to 0.95+/-0.36 in/decade) reflect differences in the technique of statistical analysis, and differences in the actual group of tide gauges used in each case.

Table 1 - Published Components of Present Global Sea-level Rise.

| SOURCE | CONTRIBUTION |
|---|---|
| Thermal Expansion | 0.08 to 0.24 in/decade |
| Mountain Glacier Wastage | 0.08 to 0.28 in/decade |
| Greenland Ice Sheet | 0.03 to 0.15 in/decade |
| Antarctic Ice Sheet | -0.24 to -0.08 in/decade |
| Reservoir Impoundment | -0.27 in/decade |
| Groundwater Withdrawal | 0.03 in/decade |
| Total Net | -0.29 to 0.35 (0.03+/-0.32) in/decade |

Table 2 - Estimated Present Sea-Level Trends From Tide Gauge Records.

| REFERENCE | ESTIMATE |
|---|---|
| Gornitz & Lebedeff, 1987 | 0.47+/-0.12 in/decade |
| " | 0.4+/-0.04 in/decade |
| Barnett, 1988 | 0.45 in/decade |
| Peltier & Tushingham, 1989 | 0.95+/-0.36 in/decade |
| Trupin & Wahr, 1990 | 0.69+/-0.05 in/decade |
| Douglas, 1991 | 0.44+/-0.04 in/decade |
| Average | 0.56+/- 0.12 in/decade |

Considering the lack of agreement between the observational data (tide gauges, Table 2) and the theoretical data (components, Table 1) it is fair to state that little quantitative understanding exists with regard to the global rate of present-day sea-level movement. It is generally accepted, however, that sea level is presently rising on a global basis, and the best estimate of that rate is between 0.3 to 0.8 in/decade. If asked to pick a single rate, many experts would pick between 0.4 and 0.6 in/decade. With this in mind, we will adopt the average of Table 2, **0.56+/-0.12 in/decade**, as our estimate of global sea-level rise. Again, one should keep in mind the lack of agreement between the *measurements* of present-day sea-level change and the *calculations* of present-day sea-level change.

2. Hawaiian Sea-Levels. Although understanding of present-day *global* sea-level movement is poor, we can have greater confidence in our understanding of present-day *local* sea-level movement in the State of Hawaii. Because Hawaii has a well maintained array of N.O.A.A. tide gauges that have been operational for several decades, local sea-level trends on the main Hawaiian islands are well documented (Fig. 21).

The Big Island is larger, and therefore heavier than the other islands. Because of it's great mass, it causes the underlying earth's crust to flex downward leading to island-wide sinking. This is called *subsidence*, and the Big Island is subsiding so much that neighboring islands (Maui, Lanai, and Molokai) are thought to be subsiding along with it. Sea-level movement on these islands then, is the sum of global rise and island sinking. This is called *submergence*. Thus, the *relative* rate of sea-level rise (or submergence) is higher at the southern islands than for Oahu and Kauai, which are less affected by Big Island subsidence. Because of this phenomenon, sea-level is rising fastest at Hawaii, a little slower at Maui, and slower still at Oahu and Kauai. The tide gauge records (Fig. 21) support this theory. The general pattern of sea-level movement in the State is controlled by individual rates of island subsidence, superimposed on the background global rate (which can be assumed constant throughout the State).

As stated, we will assume that the present-day rate of global sea-level rise is about 0.56 in/decade. We will use this number to calculate individual rates of island subsidence. Following that, we will add island subsidence rates to the IPCC (1990) projections for *future global sea-level rise*, in order to estimate future submergence rates (relative sea-level rise) at Hawaii, Maui, Oahu, and Kauai. By way of caution however, one has only to refer to Table II to see that there are as many present-day global rates as there are attempts to define it, and so we proceed with a warning to the reader that continuing research in the near future will undoubtedly provide new numbers for global rates (though probably not greatly different from our assumed average). As understanding of both present-day and

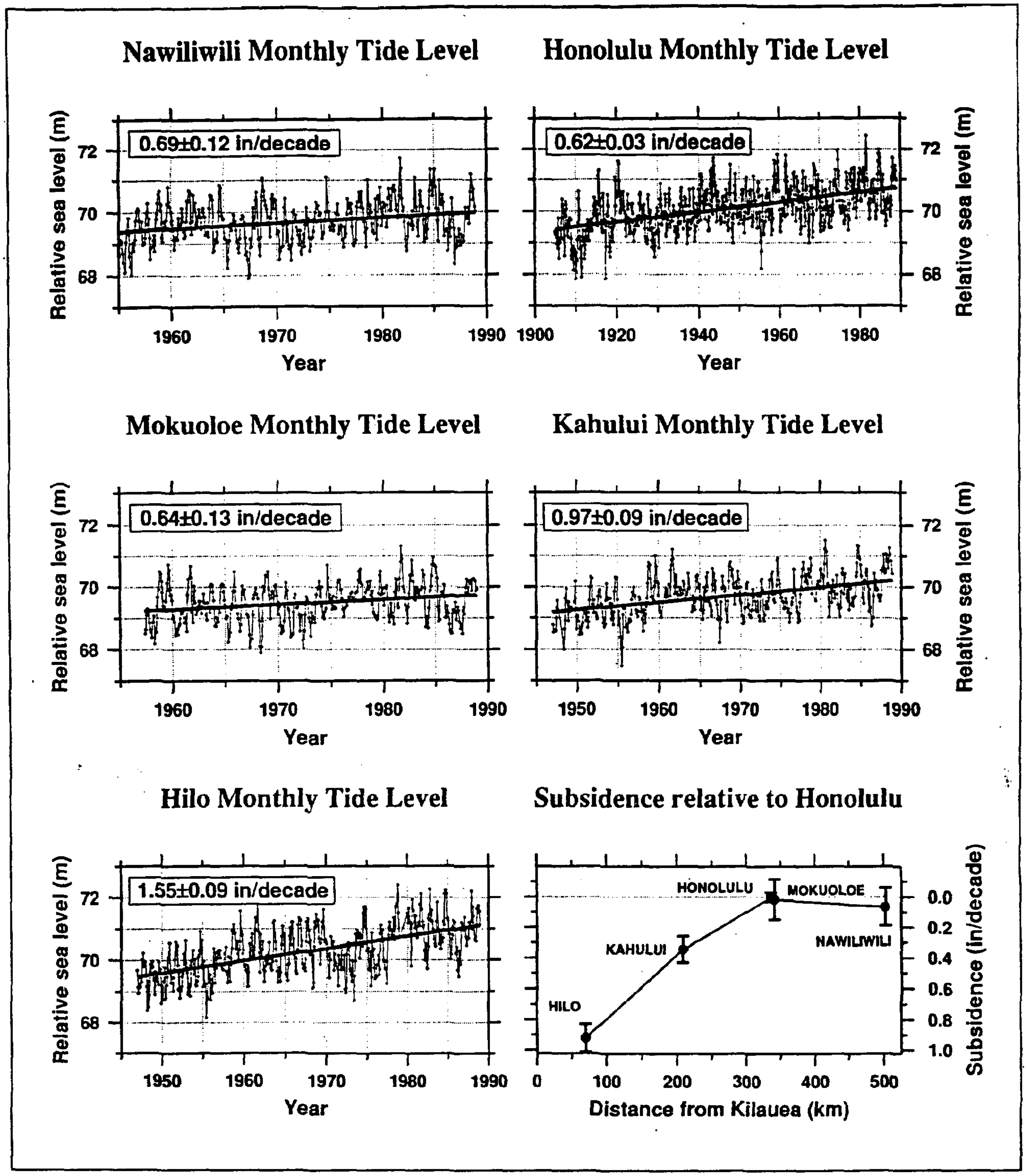



Figure 21. Local Sea-Level Trends. Local relative sea-level trends (submergence rates) in the State of Hawaii from tide gauges (from Paul Wessel, University of Hawaii, Department of Geology and Geophysics).

future sea-level rates improves, our estimates should be revised. We refer the reader to Emery and Aubrey (1991) for a comprehensive review of geologic and oceanographic factors affecting tide gauge records, we also note their conclusion that present global sea-level rise can only be bracketed between 0 and 1 in/decade.

A least-squares fit of tide gauge records (Fig. 21) shows that the rate of sea-level rise in Hilo Harbor is 1.55+/-0.09 in/decade, and at Kahului on Maui it is 0.97+/-0.09 in/decade (Paul Wessel, pers. comm.). Both of these are considerably higher than the estimated rate of global sea-level rise. Honolulu, on the island of Oahu, is thought to be generally free of the Big Island effects of enhanced subsidence (beyond the flexure), which accounts for the much slower rate of sea-level rise there, about 0.62+/-0.03 in/decade. On Coconut Island (Mokuoloe) in Kaneohe Bay, Oahu, a tide gauge records a rate of (0.64+/-0.13 in/decade). In Nawiliwili Harbor on Kauai, the tide gauge records a similar rate of about 0.69+/-0.12 in/decade (Paul Wessel, pers. comm.).

By subtracting our assumed present-day global rate (0.56+/-0.12 in/decade) from island-specific submergence rates, we calculate the island-specific subsidence rates. Hilo is *subsiding* at 0.99+/-0.21 in/decade, which is 64% of the total submergence rate (Table 3). Likewise Maui, which is *submerging* at 0.97+/-0.09 in/decade, is *subsiding* at 0.41+/-0.21 in/decade (42%). Oahu is *subsiding* at 0.06+/-0.15 in/decade, and Kauai is *subsiding* at 0.13+/-0.24 in/decade. Let us assume that the IPCC projection for accelerated sea-level rise in the next several decades is correct. The Hawaiian islands will then submerge at 2.36+/-1.4 in/decade (future global sea-level rate) plus the island-specific subsidence trends we have calculated. Accordingly, under the IPCC best estimate scenario, we can expect sea-level on Hawaii and Maui to rise at an average rate of 3.35+/-1.61 in/decade and 2.77+/-1.61 in/decade respectively; and on Oahu and Kauai we can expect rates of about 2.42+/-1.55 in/decade and 2.49+/-1.64 in/decade, respectively.

Tide gauges record alterations in sea-level position due to variations in atmospheric pressure, winds, ocean currents, long-period tides, upland runoff, vertical land movements, sediment compaction, groundwater withdrawal, and long period meteorologic events such as the El Nino Southern Oscillation (Wyrtki, 1990; Emery and Aubrey, 1991). While the net submergence values for each station are averaged over more than 30 years of data, and thus tend to smooth these various perturbations, as more data are collected the trends of these records are likely to change somewhat.

Table 3 - Hawaiian Sea Levels.

| STATION | NET SUBMERGENCE<br><br>(tide gauge trend) | SUBSIDENCE RATE<br><br>(NET SUBMERGENCE minus assumed present sea-level rise of 0.56+/-0.12 in/dec.) | PROJECTED SUBMERGENCE<br><br>(SUBSIDENCE RATE plus assumed projected sea-level rise of 2.36+/-1.4 in/dec.*) |
|---|---|---|---|
| Hilo | 1.55+/-0.09 in/dec. | 0.99+/-0.21 in/dec. | 3.35+/-1.61 in/dec. |
| Kahului | 0.97+/-0.09 in/dec. | 0.41+/-0.21 in/dec. | 2.77+/-1.61 in/dec. |
| Honolulu | 0.62+/-0.03 in/dec. | 0.06+/-0.15 in/dec. | 2.42+/-1.55 in/dec. |
| Nawiliwili | 0.69+/-0.12 in/dec. | 0.13+/-0.24 in/dec. | 2.49+/-1.64 in/dec. |

*IPCC, 1990 best estimate scenario of future sea-level rise. See Wigley & Raper, 1992 for revised IPCC estimates for sea-level rise, which fall within the range used in this report.

The range of error we attach to the projected (future) submergence rates, is the sum of the standard deviation of the calculated tide gauge trend, the error of the assumed rate of present sea-level rise, and the uncertainty of the projected rate of future global sea-level rise (IPCC, 1990). Our first source of error is in the assumed rate of global sea-level rise, 0.56+/-0.12 in/decade, which is probably somewhere between 0.40 in/decade (Wyrtki, 1990) and 0.9 in/decade (Peltier and Tushingham, 1989). Extrapolating from Table 2, we estimate a minimum subsidence rate error for each island of +/-0.12 in/decade, plus the standard deviation of the net submergence trend at each station. The projected submergence rates assume a future rise of 2.36+/-1.4 in/decade, as given by the IPCC (1990). We have added the subsidence rate error at each station to the projected submergence rate error of +/-1.4 in/decade, to derive the minimum projected submergence rate error at each station.

From the above discussion, the following conclusions can be made.

1.) Discrepancies between *estimates of the components* of global sea-level rise, and *observed trends* in the global array of tide gauge stations, are reminders that our understanding of sea-level movements is primitive, and that projections of future sea-level movements are likely equally primitive.

2.) Assuming that global sea level is rising at 0.56+/-0.12 in/decade, and that the IPCC projection of future sea-level rise is correct (2.36+/-1.4 in/decade), if island subsidence rates remain constant, we estimate that over the next century sea level will rise an average of 3.35+/-1.61 in/decade at the Big Island, 2.77+/-1.61 in/decade at Maui, 2.42+/-1.55 in/decade at Oahu, and 2.49+/-1.64 in/decade at Kauai.

3.) In the event of accelerated sea-level rise, the observed general tendency for beaches around the State to erode will be enhanced. Beaches that are presently accreting are likely to begin eroding, those that are presently eroding will begin to erode at accelerated rates.

4.) Accelerated erosion will be accompanied by accelerated shoreline recession. This tendency for beaches to move inland will result in increased shoreline stabilization, and increased interaction between stabilization structures and coastal processes. This will lead to continued, and accelerated beach loss.

5.) In addition to beach loss, sand loss will become a problem of growing magnitude. Sand loss will result from higher wave energy at the coast where shorelines are stabilized and the tendency for sand to be carried offshore by rip currents, reflected wave energy, and seaward-directed currents along the bottom.

6.) In the event of accelerated beach degradation, informed beach management will require more detailed shoreline data. Historical photographic shoreline analysis is a valuable management tool, and its development and use in the State should continue to be supported. But beach degradation can be difficult to fully quantify because aerial photographic coverage can be spotty at sites, and it relies on vegetation line movements rather than actual beach width. In developed areas, vegetation growth is sometimes stabilized by landscaping and/or vegetated stabilization structures. In such areas the technique is no longer viable because beach width changes will not be followed by vegetation changes. A more accurate and detailed technique, which also supplies useful data for artificial beach nourishment, is beach profile surveying. There is no substitute for periodic site surveys to exactly document beach state. A joint State-wide system of semi-decadal historical photographic shoreline analysis and quarterly beach and nearshore profiling would provide critical monitoring data on erosion/accretion trends. Beaches are one of the States most valuable environmental and economic assets. With this data the State would optimize the effective management of its beaches.

**D. Prediction - Accelerated Beach Loss**

All the major islands of Hawaii are experiencing erosion. In the MOESE report, known erosion rates are used to predict the amount of shoreline recession by the year 2018. On Kauai, forty-one eroding beach sites are predicted to retreat an average of nineteen feet by 2018; on Molokai, fifteen sites will retreat about twenty-one feet; on Maui, sixty-three sites will retreat an average of thirty-six feet; and on Hawaii, seventeen sites will retreat about eighteen feet. The number of eroding beaches listed here reflects a survey of a fraction of the beaches on each island. In addition, these calculations do not account for the possibility of accelerated sea-level rise, which can be expected to worsen the problem.

In many cases the erosion is at a critical point where buildings, roadways, and houses would be threatened without the protection of shoreline stabilization. When the decision is made to stop the sea and protect the land with a seawall or revetment, beach loss may occur slowly, over decades. Land ownership may change and people soon forget that there used to be a beach where now there is a wall. By default, beach loss becomes an acceptable consequence of living on the coast.

Beach loss or degradation has occurred for over 8 to 9 miles of beaches on Oahu, 2.8 to 6 miles on Maui, 1 to 2 miles on Kauai, and 1 to 1.5 miles on Hawaii. Although beach erosion is a common phenomenon for all the islands, *the recurring factor in beach loss is hardening of the shoreline*, not persistent or chronic erosion.

Stabilization of the shoreline with seawalls and revetments can be the death of beaches for several reasons. Solid structures on the beach reflect, rather than absorb wave energy so that water returning seaward carries sand away from the beach. This accelerates beach erosion. Also important is that the seawall or revetment cuts off sand exchange between the dry sand beach and inland coastal sand sources, which are quite important on Hawaiian coasts. The backshore area can be an important reservoir of sand to repair the beach after a storm or brief erosion event. With increased wave reflection and a constricted, faster longshore current, seawalls and revetments lead to a higher general energy level in the nearshore environment. This prevents the deposition of sand and ultimately forces sand to move offshore to deeper water. In addition, a lost or narrowed beach represents a loss of nourishing sand for all beaches in the longshore system. Erosion can be initiated on neighboring sections of the coast, leading to the construction of additional seawalls and revetments.

In spite of these processes, not all seawalls and revetments have led to the loss of the beach. Very infrequently, some of the structures are not located in the tidal zone where they can influence the nearshore sediment transport. Some landowners may have constructed these structures during a rare or unusual period of erosion. When more normal conditions return, these structures are significantly inland of the foreshore. Therefore, another factor that influences the impact of a seawall or revetment is the frequency that these structures are in or directly near the tidal zone where they can influence nearshore processes.

As sea-level rises, the waves reach further inland, encountering more solid structures. Those structures already within the reach of waves experience increased wave energy, further eroding any remaining sand. With continued sea-level rise in Hawaii all coastal structures will eventually increase the frequency that they are in the tidal zone. This will increase the frequency of erosional events, increase the severity and magnitude of erosion, and increase the rate and magnitude of beach loss.

Around Oahu and Kauai sea level is rising a little over one-half inch per decade. Because of the volcanic growth of the Big Island, both it and Maui are sinking. This effectively more than doubles the rate of sea-level rise on those islands (total rate of about sea-level rise is about 1 in/decade for Maui, 1.5 in/decade for Hawaii). These are historical rates based on tide gauge data over the later part of this century. If we accept widespread predictions for accelerated rates of sea-level rise in the next century, then we can expect rates of sea-level rise on Kauai and Oahu to increase to nearly two and a half in/decade, and on Maui and Hawaii to average three in/decade. Depending on *if and when* the accelerated rise begins, thirty to forty years from now the sea may be five to ten inches higher. While this may not seem like tragic news now, in fact it points to serious problems for shorelines and development in the future.

Most of our buildings around the islands stand on relatively flat and gentle coastal plains and terraces. Because of the low slope of the land surface, we can expect a landward movement of the waterline of between thirty to fifty feet or more. This rise will have two pronounced effects. First, as waves reach farther inland, more coastal property will be threatened and more of the shoreline may be armored. Property owners will seek to protect their land from erosion. Low-lying developed areas will be the first sites where increased stabilization will occur. Second, for existing seawalls and revetments which are presently inland from the tidal zone, the landward migration of the waterline will increase the frequency these structures affect the foreshore. A hypothetical increase in the frequency that structures interact with waves in the tidal zone, say for example from 20% to 50% of one tidal period, may be sufficient to initiate beach loss. Add to these two factors the storms and high waves that hit the beaches on a regular basis, and it can be concluded that future beach loss in the State may accelerate to a critical level without a fundamental change in shoreline management.

Since beaches are very sensitive to wave dynamics and the position of the water line, their loss along stabilized shorelines may be one early barometer of elevated sea level around the islands. Recent studies for the U. S. Army Corps of Engineers (Tait and Griggs, 1991) show that shorelines stabilized with vertical structures experience beach loss under long term sea-level rise. As discussed in this Chapter, accelerated beach loss is occurring in the Hawaiian Islands in association with long term sea-level rise. It is exactly these kinds of changes that are to be anticipated if sea-level rise continues or accelerates. In fact, the MOESE projections for the 2018 shoreline on Maui reflect twice the rate of recession of those on Oahu and Kauai. Since current sea-level rise on Maui exceeds twice the rate of rise on Oahu and Kauai, the higher shoreline recession rate may be a consequence of this difference in the rate of sea-level rise.

A collision is taking place. As development continues along the shoreline, the sea is rising, moving closer to development. In the process the beaches are being sacrificed. This trend is expected to increase in the coming decades because of accelerated sea-level rise and the continued use and need for shoreline stabilization structures.

**E. Mitigating the Problem - Modification of Coastal Land Use**

Intelligent stewardship of coastal resources requires balancing human expectations with coastal realities. This partnership must consider the natural processes, in light of human needs. Beach loss by stabilization is an example of where human expectations have not been balanced with reality. In trying to protect valuable coastal land from erosion to meet the expectation of living on the coast, the reality that building seawalls and revetments results in beach loss has been ignored. The need to protect coastal property with seawalls and revetments can be avoided by the recognition and consideration of coastal processes in land use planning.

Land use strategy in this study is driven by the principle that the most beneficial approach in the long run is to plan for the impacts of coastal flooding and erosion before development in order to minimize damage to natural resources and property and reduce the necessity of public expenditures to protect the development. From the examples, summaries and discussion in this chapter, the following should be considered in the planning process:

1) The loss of beach resources may occur for chronically eroding shorelines (Iroquois Point), unstable shorelines (Lanikai), shorelines that were previously thought to be accreting (Punaluu), and shorelines that are relatively stable (west end of Kahala). The common denominator for the above sites is not persistent erosion but hardening of the backshore to prevent any movement of the shoreline.

Many of the problems documented in this study could have been avoided with an adequate shoreline setback before development. Many of the lots at Kahala and Lanikai are large enough to accommodate a setback that would have been more conducive to beach preservation. Kailua Beach on the windward coast of Oahu is a good example of the benefits to the public and <u>the coastal homeowner</u> when the beach is given room to migrate (Fig. 22).

2) In general, the beach in its natural condition will be preserved even if it is chronically eroding adjacent fastlands. There are numerous examples that support this premise including Iroquois Point (see Fig. 2, 1967 photo); and the beach sector at Kahului, Maui, to the east of the Kahului Wastewater Reclamation Facility (MOESE, 1991). Wherever and whenever possible, development should be planned so that shorelines can migrate naturally. This approach could lead to the loss of fastlands. Erosion mitigation strategies such as sand replenishment could preserve the beach and eliminate the loss of these fastlands.

3) Degradation of the beach resource is a slow process. The environmental effects of poorly placed development may not be noticeable for many years. Because of the latent impacts on the shoreline, there is often a lack of accountability as to land use decisions along the coast. Planning of shoreline development needs to be

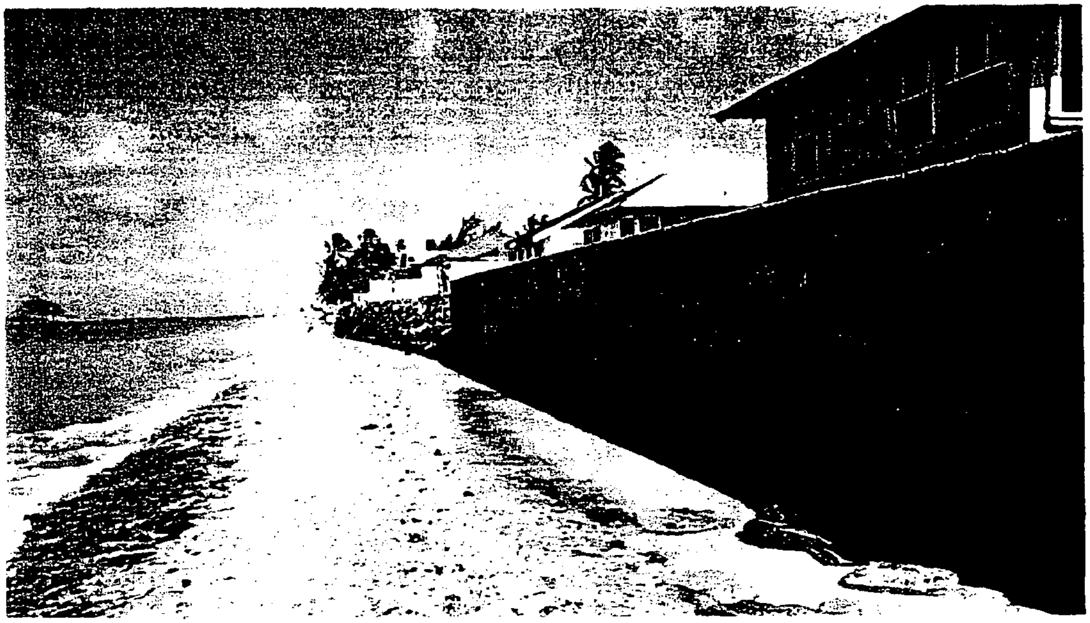


Figure 22. Lanikai and Kailua Beach, Oahu. The north ends of Lanikai Beach and Kailua Beach are both unstable. **TOP**: At Lanikai Beach, development of houses close to the beach resulted in hardening of the shoreline to protect property during a period of erosion. The beach has been lost. **BOTTOM**: At Kailua Beach, the houses are generally set far from the vegetation line. Natural fluctuations of the beach can occur without threatening private property. At Kailua, humans are living in harmony with the environment.

conducted on a long term horizon. Since proposed programs under the Federal Flood Insurance program utilize a 30 year time horizon, it is recommended that coastal development in Hawaii should be planned over a similar period to take advantage of potential benefits under this and other Federal programs.

In Chapter VIII of this report, land-use strategies are formulated which consider the above factors, as well as legal considerations and specific landowner's concerns.

**F. Cooperation, Coordination and Sacrifice**

As presented in this chapter, the problems associated with sea-level rise and loss of beaches are critical. Meaningful changes in the management of the shoreline may be required. If it is possible, reversing the historical trend will require cooperation and coordination among individual landowners, the public, the counties and the State. The strategies developed in this report emphasize cooperation among diverse groups and working relationships over adversarial ones.

To achieve the desired result, it will also require some sacrifice from all parties involved. In this study, various programs that address the shoreline problem are structured so that the burdens are shared fairly. In the long term, all parties, including the coastal landowner, may benefit.

There is still time for a well-planned response, provided the State acts with commitment and purpose. Innovative shoreline management policies are presented in this report. Early construction set-back guidelines are proposed, and there are alternatives to stabilization that are discussed in Chapters V, VI and VIII. Nevertheless, more may be needed if the beaches are to be preserved. The following should be considered: detailed feasibility studies of beach nourishment with offshore or onshore sand resources; a State-wide beach monitoring program to assemble a scientific data base supporting informed coastal zone management; development of a voluntary economic incentives plan to convert private coastal holdings to public conservation land; review of existing stabilization structures and the return of beaches to a natural state where practical.

## III. PRIVATE & PUBLIC PROPERTY RIGHTS IN THE SHORELINE

The definition of private landowner and public rights in the shoreline is essential in the development of any coastal land use policy, beach management plan, beach management district, or funding scheme in which burdens are shared among diverse parties. This topic alone could be the subject of lengthy treatise.

While considerable attention is often placed on private property rights along the coast, little consideration or understanding is placed on any public rights that may exist. All parties involved, including the State, the counties, the public and the landowners should realize that there are two sets of property rights along the coast, both private and public. Each of these rights needs to be respected and protected. That means the coastal landowner must respect the legitimate right of the State and the public in taking action to prevent the further loss of beaches. In return, the State and public need to honor the concerns and legitimate property rights of the coastal landowner.

Striking the proper balance between private and public interest is difficult because the coastal zone is a unique environment. What makes management of the shoreline so complex is that the boundary separating the two rights is not fixed but always moving, on a daily, seasonal and long-term basis. Furthermore, because of the sand exchange between offshore sand bars, the dry sand beach and backshore area, what one party does on a portion of the beach ecosystem may affect the property rights in other segments of the system.

### A. Public Property Interest

Under the public trust doctrine, the State holds certain lands in trust for the benefit of the public. The public trust doctrine is applicable in Hawaii. In King v. Oahu Railway & Land Co., 11 Haw. 717, 1899, the Hawaii Supreme Court held that lands under the navigable waters in and around the territory of the Hawaiian Government are impressed with a trust for the public uses of commerce, navigation and fishing. The Supreme Court in Oahu Ry. did not define the upper boundary of the domain of the public trust. Part of the reluctance is due to the confusion in the definition of navigable waters. This definition originally applied to those waters subject to the ebb and flow of the tide. However, many inland lakes and streams, which are subject to the public trust doctrine, are navigable but not subject to the influence of the tides. Conversely, many coastal ecosystems are subject to tidal influence but not navigable.

The United States Supreme Court in Phillips Petroleum Co. v. Mississippi, 108 S.Ct. 791, 1988, clarified this issue when they reaffirmed prior precedents and held that all lands subject to the ebb and flow of the tide, whether navigable in fact or not, are subject to the State's public trust interest. Thus in Hawaii, the upper boundary of the public trust interest extends at least to the mean high water line. The mean high water line would be the intersection of the horizontal mean high water level with the coastline.

There are two lines of reasoning that indicate the public trust doctrine extends farther inland to include the dry sand beach. First, the law of general application in Hawaii is that the boundary separating public and private interests along the shore is the upper reaches of the wash of the waves, excluding storm and tidal waves, as evidenced by the vegetation and debris line, (see e.g., Application of Ashford, 50 Haw. 314, 440 P.2d 76, 1968; County of Hawaii v. Sotomura, 55 Haw. 176, 517 P.2d 57, 1973; Application of Sanborn, 57 Haw. 585, 562 P.2d 771, 1977. Given the above cases, beaches in Hawaii are generally held to belong to the public. A 1978 addition to the Hawaii Constitution (Article XI - Section 1) states that "All public natural resources are held in trust by the State for the benefit of the people." Second, in the Sanborn case, the Hawaii Supreme Court approved their previous analysis in Sotomura, when it recognized that land below the high water mark is held in public trust by the State. The Sanborn court held that the high water mark is the upper reaches of the wash of the waves as represented by the vegetation and debris lines.

In sum, the upper boundary of the public trust doctrine extends at least to the mean high water line (the intersection of mean high water with the coast) and probably to the upper reaches of the wash of waves (usually evidenced by the vegetation line or debris line). Wherever the inland boundary is located, the disappearance of beaches as shown in Figs. 1-5 of this report may be a violation of the public trust since these changes represent serious harm to both the dry sand beach and tidelands (land between the mean high water line and lower low water).

That the State holds beach resources (tidelands or the dry sand beach) in trust for the public has important implications that are discussed below:

1) Because the beneficiaries of the trust are the public, the courts may allow

individual citizens to assert the rights of the public in a lawsuit. In Akau v. Olohana Corp., 652 P.2d 1130, 1982, the Hawaii Supreme Court held that a member of the public has standing to sue if he can show he suffered an injury in fact (the previous more difficult standard was that the citizen suffered an injury different in kind from the general public). The Akau Court recognized the trend of allowing citizen suits for harm to public trust property. The Court noted that the State, in its brief for the case, said it welcomed private suits because the State lacked the resources to pursue vigorously all such claims.

2) It is important to distinguish between the State's police power to regulate land use for the health, safety and welfare of the public and the more demanding and rigorous duty that the State has as trustee of natural resources. Under the police power, the State may decide that a rarely used beach can be sacrificed to protect private property with seawalls along an eroding shoreline. Under the public trust doctrine, the State is a trustee of a public resource and should defend, preserve, protect, maintain and perpetuate that resource. The basic tenet of the public trust doctrine was espoused by the Hawaii Supreme Court in the Oahu Railway case. The Hawaii Court adopted the reasoning in Illinois Central R.R. v. Illinois, 146 U.S. 387, 13 S. Ct. 110, where the United States Supreme Court held that title to land below the high water mark was: ". . .a title held in trust for the people of the state, that they may enjoy the navigation of the waters, carry on commerce over them, and have liberty of fishing therein freed from the obstruction or interference of private parties. . . " Without going into an exhaustive legal analysis, a generalization which can be made of the public trust doctrine is that neither the United States Supreme Court nor any state courts have disavowed the prohibition against "substantial impairment of public rights of navigation, commerce and fishing as announced in Illinois Central or Shively v. Bowlby" (Wilkinson, 1989).

The Hawaii Supreme Court has yet to fully elaborate on the range of activities covered by the public trust doctrine. In State by Kobayashi v. Zimring, 58 Haw. 106, 566 P.2d 725, 1977, the Hawaii Supreme Court suggested that recreational activities, as well as navigation, commerce and fishing may be covered by the public trust doctrine. In Terr. v. Kerr, 16 Haw. 363, 1905, the Hawaii Supreme Court employed public trust principles to enjoin the construction of a seawall on the tidelands of Waikiki. The Court stated that walls and buildings extending seaward beyond the high water mark "interfere with the rights of fisheries and of navigation by fishermen . . . . and of the right of passing between high and low water mark common to the public. And that the structures do and will interfere with navigation of canoes within the limits and below high water mark and . . . . if allowed to remain or if allowed to be completed as planned, will work irreparable damage to the rights and interests of the Territory of Hawaii." Lower courts in Hawaii have also made the connection between the loss of beach access and the duties of the State under the public trust (Lam, 1991). In Barba v. Okuna, Civil No. 4590, Findings of Fact and Conclusions of Law; Order (October 14, 1980), Hawaii's Third Circuit Court stated "Any alienation or abandonment of an established public right-of-way by the Defendant State of Hawaii which leaves the public without reasonable access to Kawa Bay and the adjacent shoreline would constitute a breach of public trust. . . The Barba case involved the blockage of vertical access to the shoreline (e.g. trails, roads and paths to the coastline). With regard to the loss of beaches as documented in this report, it is horizontal access along the coastline which is blocked. The Kerr and Barba cases indicate that the State should protect both vertical and horizontal access to the shoreline as part of their public trust duties.

3) Since it is the State that owns the beaches and is the trustee of the coastal resource, it is the State that should take the lead in managing these resources. While the counties through enabling legislation can regulate and manage shoreline development, history indicates that the greater weight has been given to county concerns as opposed to those of the State's. As a result, State property was lost (the beaches were balanced away).

In this report, the principles and concepts discussed in paragraphs 2 and 3 serve to guide the formulation of strategies and define a direction of coastal management for the State. In developing strategies, it is the State that should take the lead and assume its role as trustee of coastal resources. The philosophy of the State should be that preservation and restoration of the coastal environment should be a primary principle upon which alteration of shoreline resources should be judged. This philosophy is reflected in the strategies and options developed within this study.

**B. Private Property Interest**

All landowners, whether along the coast or not, have a bundle of property rights. There are certain restrictions the government can and cannot place on these property rights through regulation. While the government can regulate land use to a certain extent, if the regulation goes "too far" it will be recognized as a taking of property without just compensation (Pennsylvania Coal v. Mahon, 260 U.S. 393, 43 S. Ct. 158, 67 L.Ed. 322 (1922). For example, if the government were to physically occupy the land or pass a regulation that allowed others to occupy the land, the Courts would invariably find a taking, which would require the payment of just compensation to the landowner (See Loretto v. Teleprompter Manhattan CATV Corp. 458 U.S. 419, 102 S.Ct. 3164, 73 L.Ed.2d 868 (1982).

The United States Supreme Court has stated that there is no set formula for what constitutes a regulatory taking. A variety of factors are considered by the Court on a case-by-case basis. Some key factors concerning coastal regulation and shoreline setbacks are: 1) Economic Impact - e.g., does the regulation deny "all economically viable use" of the land; 2) Government Objective - is the government preventing a serious harm and nuisance or is the government securing a benefit for the public; 3) Relationship between the Regulation and the State Interest - does the regulation "substantially advances a legitimate state interest"; and 4) Property Expectations - what are the "investment backed expectations" of the landowner.

Recently, the United States Supreme Court ruled on a pivotal case that affects government regulation of property (see, e.g., Callies, 1992). In Lucas v. South Carolina Coastal Council, 304 S. C. 376, 404 S. E.2d 895 (1991); cert. granted (U.S.S.C., Nov. 18, 1991) (No. 91-453), the landowner Lucas purchased two lots in 1986 for a price of $975,000. Lucas planned to build two single family dwellings, one for his family and the other to place on the market. In 1988, South Carolina passed the Beachfront Management Act, which imposed strict shoreline setbacks to prevent erosion problems. As applied to the Lucas property, the setback prohibited construction of habitable units seaward of setback that was based on a 40-year erosion rate plus 20 feet as an additional buffer. There were no exceptions, S. C. Code S 48-39-290(A) (Supp. 1988).[1] Even though Lucas conceded the validity and purpose of the South Carolina Act, he claimed that the

[1] The Beachfront Management Act was later amended to allow special permits or variances to build closer to the beach under certain conditions, S. C. Code s 48-39-290 (1990). However, the United States Supreme Court ruled on the viability of the Beachfront Management Act in its preamended version (1992 WL 142517). The Court held that Lucas alleged injury-in-fact with respect to the preamended Act, and it would not accord with sound practice that he pursue a late created procedure before his case could be heard.

setback was a taking since "all economically viable use" of the land was lost. The South Carolina Coastal Council maintained that regardless of the economic impact to the landowner, the State can regulate land to prevent a serious public harm or a nuisance.

The trial court held that Lucas's properties had been "taken" by the Act and ordered the respondent, South Carolina Coastal Council, to pay "just compensation" in the amount of $1,232,387.50. The South Carolina Supreme Court reversed the trial court and held that the Beachfront Management Act did not amount to a taking since it prevented a serious public harm, 304 S. C. 376, 383; 404 S. E.2d 895, 899 (1991). The South Carolina Supreme Court's holding in Lucas is in line with other cases dealing with shoreline setbacks and the takings issue (see, e.g., McNulty v. Town of Indialantic, 727 F. Supp. 604, M.D. Fla. 1989; see generally, Hwang 1991).

The United States Supreme Court reversed the South Carolina decision (1992 Westlaw 142517). The U. S. Court held that regulations that deny a property owner of all "economically viable use" of the land constitute one of the discrete categories of regulatory deprivations that require compensation, regardless of the public interest advanced in support of the restraint. Furthermore, the Court stated that the distinction between regulations that prevent harm versus those that confer a public benefit is difficult, if not possible to discern on an objective basis. Therefore regulations that prevent a harm cannot form the basis for departing from the Court's categorical rule that total regulatory takings must be compensated for.

Nevertheless, the Court left open the door to State regulation to prevent serious public harm, even if all use is deprived. The Court stated that no compensation is owed if the State regulation simply makes explicit what already inheres in the property itself, "in the restrictions that background principles of the State's law of property and nuisance already place on land ownership." Thus, the U. S. Court remanded the case to South Carolina to address this state-law question. In order for the South Carolina Coastal Council to win their case, they must identify background principles of nuisance and property law that prohibit the uses that Lucas intends on his property.

The majority gives examples of the types of regulations that may be constitutionally valid. For example, the owner of a nuclear generating plant may be ordered to remove all improvements from the land upon discovery that the plant sits astride an earthquake fault. The example given by the Court that is more applicable to coastal regulation is that of flood regulation. The Court states that the owner of a lake bed, "would not be entitled to compensation when he is denied the requisite permit to engage in a landfilling operation that would have the effect of flooding others' land. . . Such regulatory action may well have the effect of eliminating the land's only economically productive use, but it does not proscribe a productive use that was previously permissible under relevant property and nuisance principles. The use of these properties for what are now expressly prohibited purposes was always unlawful." 1992 Westlaw 142517, p. 25.

The majority does not discuss the similarity between regulating an erosion zone as opposed to a flood area. It is relatively simple to document examples where attempts to control erosion on one land transfer the erosion problem to anothers' land. In fact, Chapter 2 of this report contains numerous examples where landowner activity has the effect of exacerbating erosion on adjacent private and public land.

If a State was to pass strict setback regulations, an attempt should be made to define background principles of nuisance and property law. The public trust doctrine, discussed in part A, is one common law theory that may restrict certain activities near public trust land. For example, if the development on a lot adjacent to an erosion zone would lead to the loss of public trust land, then the <u>Lucas</u> Court indicates a regulation that makes explicit a pre-existing restriction may be valid. To pass a strict restriction, documentation similar to that in Chapter 2 would be needed to define the impact on public trust land. Documentation on the individual lots or the locality in question would also be required.

It should be reemphasized that the <u>Lucas</u> case deals with the issue of regulating small lots to the extent that all use of the property is gone. For small lots that have been subdivided but not yet developed, land use options are limited since a shoreline setback that protects the beach and preserves buildable area may be mutually exclusive. <u>The zoning strategies in this report should not be affected since they are designed to affect large tracts of land that have not been subdivided or zoned for urban use</u>. Through innovative strategies, it is possible to develop a setback that preserves the beach and maintains or enhances economically viable use of the land (Chapter VIII).

# IV. MANAGEMENT OBJECTIVES & STRATEGY

## A. Objectives

In Chapter II, the loss of Hawaii's beaches was documented as resulting from the combination of long-term sea-level rise and extensive shoreline hardening. This report has three objectives that address this problem. The objectives pertain to the following levels of use along the coast:

1) Undeveloped Land - One purpose of this study is to develop a strategy for undeveloped land to ensure that beach resources are not threatened. Generally, it is easier and more cost efficient to preserve a beach through regulatory controls than to recover a beach through engineering solutions. For land that is undeveloped, regulatory controls will be the major management tool. Factors that will be considered in formulating land controls include beach preservation, landowners property rights, and other legal and economic factors.

2) Developed Land - (No Seawalls or Revetments) For developed beaches that have not been hardened, the goal is to devise options that preserve the beach yet provide protection to the landowner. This means finding alternatives to seawalls and revetments. New options for landowners will have to overcome the difficulties of cost and regulatory compliance for activities makai of the vegetation line. It is through the Beach Management District that these problems can best be addressed. In those instances where technical, legal or financial difficulties leave no other alternative, buried erosion control structures on the landowner's property may be the preferred method of protection (see e.g., DHM, inc., September, 1990). Nevertheless, because of the continued rise in sea-level, this option may be temporary.

3) Developed Land - (Seawalls and Revetments - Beach Lost) For shorelines that are developed and the beach is lost, an attempt should be made to restore lost resources. Restoration can be provided either by sand replenishment through the BMD option or through a voluntary program of retreat from the shoreline based on the provision of economic incentives.

The ultimate goal of this study is to formulate a menu of options that are technically, economically and legally feasible for the State and landowner. All the options developed in this report will be preferable, from a perspective of preserving the beach, over a seawall or revetment. It is hoped that at least one or more of the alternatives will be applicable for every stretch of beach along the State.

**B. Strategies**

Five basic strategies are employed in this report to develop options that preserve the shoreline. They are as follows:

1. Develop the Beach Management District. Regarding an erosion control response, there are alternatives to seawalls and revetments that may be less harmful to the beach yet considerably more difficult to implement because of cost or permitting. Through BMDs, it is possible to raise the viability of other technically feasible options so that they become realistic alternatives to landowners. Structural and nonstructural options such as offshore breakwaters or sand replenishment will be investigated within the BMD concept.

It is realized that the formation of BMDs may not be technically, economically or legally feasible for every stretch of beach in the State. Therefore other strategies are required to address the pervasive problem of sea-level rise, shoreline hardening and beach loss.

2. Implement Economic Mechanisms in Beach Management. In the field of Federal environmental regulation, Congress and the Environmental Protection Agency are increasingly exploring the utilization of economic incentives for activities which preserve the environment and economic disincentives for activities that degrade the environment. Economic disincentives can come in the form of taxes, fees, or assessments. Economic incentives may include tax credits, tax deductions, subsidies, and tradable privileges to conduct certain activities near the shoreline. The advantage of a program of economic mechanisms to achieve environmental goals include the following:

(a) Reduced Government Expenditures - Economic mechanisms may reduce government expenditures for environmental programs. This is an important consideration during a time of tight budget constraints.

(b) Revenue - Economic disincentives are a source of revenue for other environmental programs.

(c) Flexibility - Fees or taxes on unavoidable activities that degrade the environment can contribute revenues to other programs that preserve or restore the environment in another area.

(d) Business Planning - Economic disincentives allow businessmen to plan their activities with the environment. Since a price is put on activities that degrade the environment, businesses can formulate other alternatives to achieve a lower cost while preserving the environment.

For this study a limited program of economic measures will be used to develop beach management strategies. Economic incentives and disincentives could be used to deal with the significant problem of illegal seawalls and revetments. In addition, economic incentives could provide for a voluntary program to relocate buildings and erosion control structures inland.

3. Achieve Regulatory Efficiency. When landowners build seawalls or revetments on their land, they may need only one variance from the appropriate county agency. However, if they wish to protect their property with erosion-control measures that are less harmful to the beach, such as beach replenishment, a breakwater, or a terminal groin, up to six permits may be required. Depending on the type of activity to be conducted, the following may be required:

County Permit - If the landowner's activities extend mauka of the shoreline, for example, a groin which goes from the backshore into the water, a county variance would be required pursuant to appropriate setback regulation.

Department of Land and Natural Resources - Land makai of the shoreline is conservation land. Any use within the conservation areas would require a Conservation District Use Permit. In addition, an environmental assessment would be required according to Chapter 343, Hawaii Revised Statutes. If adverse impacts are found, an Environmental Impact Statement may be required.

Department of Transportation - Under Chapter 266-1 of the Hawaii Revised Statutes, all ocean waters and navigable streams are under the care and control of the DOT. For ocean dredging, filling, construction and dumping of materials below the mean water line a Shorewaters Permit is required. The DOT permit is processed and issued concurrently with the Conservation District Use permit from the DLNR. However, DOT has the prerogative to disagree with the Conservation

Permit and may request that the applicants obtain a Shorewaters permit.[2]

Army Corps of Engineers - If the activities of the landowner extend seaward of the high water line, then a permit from the Army Corps of Engineers may be required under section 404 of the Clean Water Act. Corps permits are required for dredging, mooring buoys, the discharge of fill material, and the construction of erosion-control structures such as groins or breakwaters. That a Corps permit is required triggers the requirement for the following two permits, as mandated by Federal law, and administered by State agencies.

Coastal Zone Management Program - Under the Federal consistency provisions of the Coastal Zone Management Act of 1972, all Federally licensed or permitted activities affecting the coastal zone must be conducted in a manner consistent with the State's approved management program. For Hawaii, the activities must be in accordance with the objectives and policies of Chapter 205A-2 of the Hawaii Revised Statutes.

Department of Health - According to Section 401 of the Clean Water Act, any applicant for a Federal license or permit to conduct any activity that may result in a discharge into the navigable waters shall provide the licensing or permitting agency a certification that the discharge will comply with applicable provisions relating to water quality standards. Monitoring of water quality is required before, during and after the proposed activity.

The regulatory process itself can deter a landowner from selecting an erosion control option that is less harmful to the environment. Although efforts have been made to streamline the process, further measures may be necessary. Achieving regulatory efficiency is especially important since programs to preserve or restore beaches may take additional regulatory controls. Such regulations will be greeted with skepticism unless the regulatory process can be made less burdensome, even with the new controls. In this study, recommendations for additional efficiency measures and coordination are made so that even with new shoreline programs, the total number of required approvals is reduced.

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[2] On July 1, 1992 the boating program functions and all boating facilities will be transferred from the Harbors Division of DOT to DLNR. Jurisdiction of this program will be with the DLNR, Division of Boating and Ocean Recreation.

4. Enforce Existing Regulations. Additional protection of the shoreline may be obtained by enforcing existing coastal regulations. In the 1991 report, Recommendations for Improving the Coastal Zone Management Program, it was recognized that violations of the SMA permitting process and shoreline setback provisions are a major problem. One reason for the violations is the lack of sufficient enforcement capacity by the counties. In this report, suggestions are made for improved enforcement of existing regulations.

5. Offset Burdens with Benefits. There are three major approaches to deal with coastal erosion, beach loss and sea-level rise. The State may decide that the present system of beach management is working and no further action is required. As discussed in Chapter II, this approach would lead to continued or accelerated degradation of the coastal environment and increased risks to landowners.

A second strategy is to adopt a strict policy of retreat from the coastline similar to that enacted by South Carolina. In South Carolina's Beachfront Management Act, there are strict prohibitions on erosion control structures and new development seaward of a forty year erosion setback. The advantage of the South Carolina Act is that it protects coastal resources and is relatively easy to administer. The disadvantage is that the Act may intrude on private property rights. The South Carolina law does test the limit on the extent government can regulate private coastal property for the good of the public (see e.g., Lucas v. South Carolina Coastal Council, 404 S.E.2d 895, (S.C., 1991); cert. granted 112 S.Ct. 436, 116 L.Ed.2d 455, 60 U.S.L.W. 3374 (U.S.S.C., Nov. 18, 1991) (No. 91-453); and Beard v. South Carolina Coastal Council, 403 S.E.2d 620 (S.C.1991); cert. denied, 112 S.Ct. 185, 116 L.Ed.2d 146, 60 U.S.L.W. 3262 (U.S.S.C., Oct. 7, 1991)(No., 91-137). In Hawaii, a strict policy of retreat from the coastline may encounter strong opposition that could disable any proposals to protect the shoreline.

A third approach, and the one that is suggested in this report, is to formulate an erosion management program in which burdens placed on affected parties are compensated with other benefits. The drawback of this alternative is that the shoreline management program becomes more complex since it requires the development of a benefit for every burden imposed. This alternative also requires strong cooperation between the State and county governments. The advantage of offsetting burdens with benefits is that it can reduce political opposition from landowners and developers. Therefore, meaningful programs can be implemented to preserve the State's shoreline.

# V. BEACH MANAGEMENT DISTRICTS

The Beach Management District would be used to pay for the design, analyses and capitalization of erosion-control measures. The advantage of forming a district is that it provides economies of scale. For many erosion control projects, the cost to a single homeowner for a comprehensive coastal study may be more than the cost to build a seawall (Edward K. Noda & Assoc., 1989). However, if many landowners were to split the cost of the study, they would benefit since alternatives other than seawalls may be developed in the coastal analysis. Through the cooperation of landowners, the counties and the State, it may be possible to develop and finance alternatives such as offshore structures, sand replenishment, or a field of leaky groins.

Many coastal states have established Beach Management Districts (BMDs) to deal with coastal erosion. The success of these programs has varied on the type of district established and the level of cooperation from the State and local governments.

## A. The District Structure

There are numerous variations of the district concept that have been used for capital improvement projects. They include the improvement district, the overlay district, and the special taxing district. Coastal States that have established BMDs have used one or a combination of the three forms. The various forms of the district are discussed in order of increasing complexity.

1. The Overlay District.[3] The idea behind an overlay district is that certain areas may be so unique in terms of land use, historical significance, scenic beauty or economic value that another layer of regulation or additional restrictions may be needed for the building and design of structures. In the Hawaii State Land Use Enabling Act, (HRS S 46-4) the counties are given the power to determine land areas in which particular uses may be subjected to special restrictions. Examples of districts on Oahu with another layer of regulation include Diamond Head and Punchbowl craters, the Hawaii State Capital, Chinatown, Thomas Square/Honolulu Academy of Arts, Waikiki and Haleiwa (Dept. of Land Utilization, Land Use Ordinance S 7.20-7.90). In addition there are overlay regulations governing

[3] Also known as a special district in the Oahu Land Use Ordinance.

specific Federally established Flood Hazard Districts (LUO S 7.10).

According to the Kauai County Zoning Ordinance, special overlay Shore District Zones may be established (Ord. No. 164, August 17, 1972). For the Shore District, the Planning Commission of Kauai was supposed to develop a Shoreline Special Treatment Zone Plan which delineated the boundaries of the Shore District. New developments within the zone are to address certain environmental issues such as water quality or public use of the ocean. In addition, the Shore District has some restrictions on seawalls, bulkheads and other erosion control structures. These overlay Shore Districts have yet to be implemented by Kauai (DHM, inc., 1990).

Previous studies in Hawaii have proposed the establishment of overlay districts (see, e.g., Edward K. Noda & Assoc., 1989; DHM, inc., 1990; Sea Engineering, 1991). At the county level, overlay districts may be useful for shoreline sectors with unusual problems or unique characteristics. For example, the beach at Waikiki is unique from other sandy shorelines in terms of visitor usage, types of activities and economic importance. For Waikiki, a special layer of regulation and unique standards to protect the beach may be warranted.

Overlay districts may be useful if State legislation is ineffective to prevent erosion problems at a particular locality. In this case the counties can establish an overlay district with more stringent zoning controls for the area. Overlay districts may also be needed if the counties were to develop a special program to grant height and density variances for those landowners who were subject to an increased shoreline setback (see proposal - Chapter VIII).

While the overlay district may be useful for certain areas, its application to most of Hawaii's beaches may be cumbersome. In considering the utility of an overlay district as a method of regulatory control, one consideration would be how unique the problems are at a particular locality. If the problems associated with coastal erosion and beach loss are limited to a few sites, then the formation of overlay districts to counter the problem may be appropriate. However, if the coastal problems are extensive, then it may be more efficient to apply meaningful regulatory guidelines and criteria at the State or county level.

Previous studies indicate that the problems associated with erosion and beach loss are extensive. According to the MOESE report, sixty-three sites on Maui will retreat an average of thirty-six feet by the year 2018. The examples at Kahala, Punaluu and Lanikai on Oahu (Figs. 3-6) indicate that beach loss is not confined to chronically eroding shorelines but also to stable beaches and areas that were formerly accreting. In addition, the difficulties associated with accelerated sea-level rise are expected to increase the number of trouble areas along the coast. Another important consideration is that the State is trustee of the beach resource. As a trustee, effort should be made to protect all beaches, not just those with unusual characteristics. Therefore, the number of beaches to protect by special overlay regulation could be considerable.

The establishment of numerous overlay districts along the Hawaii coastline may be burdensome. More efficient in a statewide beach management program may be effective controls at the State or county level. This is not to discount the important value of the overlay district. If the State were unable to develop meaningful guidelines for beach management, it may be up to the counties to take the initiative and develop individual overlay districts for various areas.

The overlay district and the improvement district are not mutually exclusive. Each is suitable under different conditions. In many cases, both may need to be utilized. Since much of the legal structure is already in place to develop the overlay district, more time was spent in this report to develop the improvement district. In Chapter X, an attempt is made to apply both the improvement and overlay district concept to two different beach areas.

<u>2. The Improvement District</u>. For an improvement district, a special assessment is charged upon lands deriving some benefit from a nearby capital project to defray some of the cost of the improvement. The charge of assessments must be limited to situations where there is some benefit to the property assessed. The charge cannot be for more than the benefit received nor for more than the cost of the improvement (Hagman & Juergensmeyer, 1986).

Traditionally, assessments were used to pay for improvements to streets, sidewalks, lights and sewers. In the Hawaii State Land Use Enabling Act, (HRS 46-1.5), the counties are given the power to provide by ordinance for the funding of improvements or maintenance within a district by the use of assessments. In Oahu's special assessment ordinance, assessments may cover activities to establish highways, extend or widen streets, improve sanitary and drainage systems, and acquire property for playgrounds and public beach parks (City and County of

Honolulu, Revised Ordinances of Honolulu, Chapter 24).

Improvement districts may also be used as a tool to finance offshore breakwaters, sand replenishment, or other non-traditional erosion control projects (Edward K. Noda & Assoc., 1989). Numerous coastal states have used the improvement district concept to finance erosion mitigation projects. In Connecticut, special assessments for erosion mitigation are allowed for the construction of groins, jetties, seawalls, revetments and other structures and facilities useful in preventing damage from floods or erosion (Conn. Gen. Stat. Ann., Title 25-Water Resources, S 25-71). In Rhode Island, assessments are made on property which benefit from protective works along the shore (R.I. Gen. Laws S 46-3-12). For North Carolina, improvement districts at the county level may be made for water systems, street widening and for beach erosion control projects (N.C. Stat S 153A-185). In Maryland, the State assesses shoreline properties that benefit from the design and installation of bulkheads, groins, and other devices. Benefited properties include land immediately abutting the waters of Maryland that receive protection from an erosion control project (Md. Nat. Res. Code Ann. S 8-1001).

The improvement district is a valuable tool that can be of use for selected portions of the coast. It is recommended that improvement districts be formed for erosion mitigation projects that benefit the State and private landowner so that the costs can be shared equitably. The improvement districts can be modeled after the regulations from other coastal states and Oahu's Improvement District Ordinance.

<u>3. Taxing Districts.</u> Taxing districts perform many of the functions of an improvement district; however, the revenues that are collected are not limited to a single purpose or improvement. Taxing districts are organized into small governmental entities, with a structural form, the right to obtain and dispose of property, and the power to issue bonds. These districts are usually run by elected officials and are subject to a high degree of accountability. They have been used to create roads, bridges, police and fire protection services and recreational facilities (Hagman & Juergensmeyer 1986).

In Hawaii, legislation has been proposed to give the counties the authority to establish taxing districts. In 1990, Senate Bill #3293 proposed the establishment of Community Facilities Districts in which taxes on property did not have to be apportioned on the basis of benefit to the landowner. This bill never passed out of conference committee.

In Florida, beach erosion and mitigation projects may be initiated at the State or county level. At the county level, Beach and Shore Preservation Districts are established with many of the characteristics of an overlay and taxing district. Beach and Shore Preservation Districts at the county level are run by a board of county commissioners who are elected officials (Fla. Stat. Ann. S 161.25). The board has the authority to install erosion control structures, make contracts, establish regulations, acquire land, exercise the power of eminent domain and levy taxes within the district.

In New Jersey, beach erosion control districts are formed at the municipal level (N. J. Stat. Ann. S 40:68-27). The district is run by 3 elected commissioners who comprise the Beach Erosion Control Commission. The district may prepare plans and specifications for the construction of jetties, bulkheads or other facilities designed to prevent erosion. In addition, the district may issue bonds and raise taxes within the district to pay for the bonds (N. J. Stat. Ann. S 40:68-42).

The establishment of a taxing district such as in Florida or New Jersey is a complex procedure. For Hawaii, a Beach Management District using a taxing format is not recommended because the magnitude of the shoreline problem would require the establishment of numerous entities or local governments around the islands. This may result in duplication of efforts and inefficiency.

**B. District Formation**

In Oahu's Improvement District Ordinance, 60% of the landowners and lessees to be assessed may petition the City Council for a certain improvement within a proposed district (Revised Ordinances of Honolulu, Chapter 24, Sec. 24-3.2). The petition must be accompanied by maps, surveys, plans and other preliminary data which the City Council use to evaluate the petition. Alternatively, the city council may, by resolution, propose the formation of a district. In either case, a notice and public hearing are required that allow all affected property owners an opportunity to express objections or suggest modifications to the proposed district.

In Maryland, the owner of any property abutting any body of water of the State may file a written application with the Department of Natural Resources requesting assistance in the design, construction, and financing of a shore erosion control project for the property (Md. Nat. Res. Code Ann. S8-1001). The applicant must state on the application that they are responsible for the maintenance of the project after its construction.

It is suggested that provisions are created which allow the establishment of Beach Management Districts, where they are feasible, upon the initiative of the State, the county, or a group of coastal landowners. It would be the proposed Division of State Beaches that would evaluate the petition, and decide on the viability of a potential project for erosion mitigation.

**C. Landowner Cooperation**

In the establishment of an improvement district, a critical issue is how to get a group of landowners to consent or cooperate to a major improvement project. For Oahu, an improvement district requires the consent of at least 60% of the landowners and lessees to be assessed (Revised Ordinances of Honolulu, Chapter 24, Sec. 24-3.2). While only 60% of the affected parties must consent, 100% of the affected parties pay an assessment according to the specific benefit received.

Between 1915 and 1987, over 360 street and sewer improvement projects have been completed on Oahu. The first improvement district was the Manoa Improvement District No. 1, initiated in 1915. More recent improvement districts were in Ewa Beach, Waimalu, and Halawa (Dept. of Public Works, 1987). The Department of Public Works often encounters the situation where most landowners consent to an improvement district except for a few holdovers who refuse to pay. One generality that can be made is that there appears to be more willingness for landowners to participate in the payment of a sewer improvement as compared to road improvements (Alex Ho, pers. comm., Department of Public Works). This may be because the Department does not allow the non-consenting landowner to hook up onto the new sewer until payment is made. There may also be the perception, whether true or not, that the landowner benefits to a greater degree from a sewer project versus a road improvement. For road improvement projects, additional effort may be required to get non-consenting landowners to cooperate. In some cases a tax lien may be placed on the property.

In the Hawaii Revised Statutes S 206E-6, authority was given to the Hawaii Community Development Authority (HCDA) to develop a district-wide improvement program. An improvement project in the HCDA is initiated by a 2/3 approval of the authority (the board), and the governor's consent (Clayton Goo, pers. comm., HCDA). Although landowner consent may be considered to initiate the improvement district it is not a requirement in the formal establishment of the district.

The experiences on Oahu with improvement districts indicate that although landowner cooperation may be an obstacle to district formation, this need not be an insurmountable problem. If landowners can recognize a specific benefit from an improvement project, they may be more willing to cooperate in the financing of the project. With regard to beach improvement projects, the benefits to the property owner include the protection of valuable oceanfront property, increased recreational opportunities and improved esthetics.

Many coastal states that have provisions for Beach Management Districts have failed to implement these ideas. One common obstacle is getting landowners to agree on an erosion control strategy and pay schedule. Landowners tend to be very independent when a solution to a problem deals with their own property and pocketbook.

A lack of landowner cooperation has been a key hurdle in establishing BMDs on a comprehensive basis in Massachusetts (Steve Blivens, pers. comm., Mass. Coastal Zone Management Program). For example when, an inlet broke through the barrier island at Chatham near the Cape Cod national seashore, the local officials wanted a plan to control erosion that covered the whole stretch of shoreline. The landowners preferred to control erosion on a parcel by parcel basis. One reason landowner cooperation in Massachusetts is a problem is that there is little participation by the State in coordinating a beach district or contributing to its cost. While the State prefers coordinated action by the landowners, they prefer to remain uninvolved by leaving the problem to the local government and private landowners. Although there are legislative provisions for the formation of beach management districts at the local level, there has been little success in forming such districts. <u>An important lesson can be learned from the experience in Massachusetts. Without an active coordinating agency or an economic incentive to cooperate, landowners prefer to take action on their own</u>.

One State that has experienced success in the establishment of BMDs is Florida. Beach and Shore Preservation Districts in Florida are covered under the

Beach and Shore Preservation Act. Several districts have been established and several more are proposed to replenish beaches with offshore sand. Funding for projects is derived from the Beach Management Trust Fund, where money is derived from State appropriations and permitting fees (Fla. Stat. Ann. S 161.0535, S 161.091). Payment for beach renourishment in Florida is shared, with 75% of the cost to be paid from the Beach Management Trust Fund and the remainder from the local government (Fla. Stat. Ann. S 161.101). One reason for the success of the district concept in Florida is that the State and local governments provide considerable financial support for various replenishment projects. All funding comes from State appropriations or local governments.

Maryland has also been successful in the formation of beach erosion control districts. In Maryland, a shoreline sector may be divided into physiographic units, which are portions of the coast with similar nearshore processes. For a physiographic unit project to be established, all property owners within the physiographic unit must consent. A physiographic unit project may not begin unless every landowner participates in the planning, construction and financing of the project (Md. Nat. Res. Code Ann. S 8-1003). In Maryland, erosion control districts have been formed along the Atlantic Ocean and in Chesapeake Bay (Mike Helta, pers. comm., Maryland Department of Natural Resources). Along Chesapeake Bay, several projects to construct bulkheads and offshore breakwaters have been administered by the Department of Natural Resources. The Department is very active in helping the landowner. The Department provides, through a Shore Erosion Control Construction Loan Fund, interest free loans for the design and construction of erosion control structures. In addition it selects consultants for district projects, walks the applicant through the permitting process and handles the administration of the project. That the Maryland Department of Natural Resources administers beach districts has been a relief to city and county governments. Many of the local government agencies do not have the expertise or personnel to run a project to control beach erosion.

The success of the district program in Florida and Maryland could be attributed to the financial support offered by the State in paying for the project or in providing interest free loans. In addition, both states play an active role in coordinating the beach project. For Hawaii, it is suggested that a Division of Beaches be established to help coordinate the activities of landowners and to administer a dedicated State Beach Fund that would provide economic incentive for landowners to participate in the Beach Management District.

### D. Liability

There may be some concern about the liability to the county or the State if they participate in a BMD by building, designing, initiating, administering or permitting an erosion control structure that eventually fails. Many coastal states have solved this problem by requiring the homeowners, or other parties to sign an indemnity or hold "harmless clause" that serves to relieve the State or local government from liability (See, e.g., Md. Nat. Res. Code Ann. S 8-1001; N. J. Stat. Ann. App. A:9-51.8). In general, the clauses require that the property owners agree in writing, before a beach management district is established, to indemnify and hold harmless the city or the State from any injuries or damages arising directly or indirectly from a proposed improvement. Similar provisions would be required for any district that was established in Hawaii.

The homeowner should be aware that the ocean and coastal environment is a dynamic environment. Absolute safety from natural forces is impossible for development along the shore. Structural failure is always possible, whether the structure is a seawall, a revetment, a series of groins or a breakwater.

The establishment of a BMD is a benefit to the landowner since it provides protection and adds value to the shoreline property. In addition, part of the cost is absorbed by the city and State. Therefore, it would be a small request to ask the landowner to indemnify the city or the State before such a project is undertaken.

In addition to liability from coastal landowners, the State should be concerned about an injury to a member of the public that is directly or indirectly related to the formation of a BMD. It is for this reason that a proposed Division of Beaches would need to monitor beach improvement districts to make sure no dangerous unnatural conditions exist such as a failed erosion control structure. If dangerous unnatural conditions are present, the State would need to warn the public until necessary repairs are made to correct the condition (See, e.g., Littleton v. State of Hawaii, 66 Hawaii 55; 656 P.2d 1336, 1982; in some instances the State is required to warn the public of dangerous unnatural conditions such as large telephone poles in the water).

### E. Procedures

For many shorelines, there may be no structural or non-structural options within the district setting that are technically, financially or legally feasible. Therefore, guidelines and criteria would have to be adopted for the review of petitions to form Beach Management Districts.

For those shorelines where a district can be formed, specific regulations need to be established regarding the procedures for establishing such a district. This may cover notice requirements for landowners, hearing requirements for the public, assessment formulae, payment plans, maintenance schedules, indemnity agreements, appeals processes, provisions for lessees and all other matters related to organizing and administering a BMD. It would be the proposed Division of State Beaches that could make these rules. Many of these rules could be modeled after the regulations and statutes for improvement districts in other coastal states, Oahu's improvement district ordinance, or the Hawaii Community Development Authority's rules for a district-wide improvement program.

**F. Temporary Protection**

The formation of a Beach Management District may take several months or over a year, depending on the financing and type of project to be undertaken. During the time that it takes to implement a shoreline protection project, the landowner's property may be threatened by erosion. Therefore, temporary erosion protection devices need to be allowed such as low sandbag bulkheads or low weir groins. It would be the proposed Division of State Beaches that would investigate, or cause to be investigated, the types of suitable temporary structures. The Division would also make the guidelines and regulations for temporary shore protection.

**G. Applicability**

A Beach Management District may be organized in the form of an overlay district, an improvement district, or as a hybrid form, using a combination of both concepts. Overlay districts can be created that control or guide the types of erosion control structures along the shoreline. A proposed Division of Beaches could help the counties to develop guidelines for the initial design of suitable erosion control structures for the particular beach sector. An overlay district could then be established that forbids new or illegal erosion control structures, except for those structures that are in compliance with the initial guidelines. Coastal homeowners would then have the option of complying with the overlay regulation individually, or in cooperation with other landowners, so that the cost of additional engineering studies or the construction of the actual structures could be shared among many parties.

It is anticipated that for a sand replenishment project, an overlay and improvement district would be required. An overlay district may be necessary to prepare the shoreline for subsequent sand replenishment. Before sand replenishment takes place, as many seawalls as possible should be removed to prevent wave reflection off of vertical walls. Waves reflected off these walls may carry replenished sand offshore during storm events. Structures such as a buried revetments may be substituted for the removed seawalls. For a sand replenishment project, the creation of an improvement district would also be needed so that the costs can be shared by all beneficiaries of the project.

The formation of an improvement district along the shoreline is not feasible for all beach sectors. Some beaches, such as on the north shore of Oahu have such high wave energy or large seasonal changes that the use of sand replenishment or offshore structures to protect coastal property would be too costly or impracticable. In other sections of the coastline, the landowners may be so close to the surf zone that the use of measures other than a seawall or revetment may not provide adequate shoreline protection.

Since an improvement district is not suitable for all sandy shorelines, other beach protection strategies or management options are presented in this report. In later chapters there is a review of nonstructural and structural erosion mitigation measures. While many of these options would be available to the homeowner only through the establishment of a Beach Management District, some of the options, such as gently sloping buried revetments could be implemented independent of district formation. In Chapter VIII, regulatory strategies are considered as additional means to manage the shoreline.

# VI. NONSTRUCTURAL AND STRUCTURAL OPTIONS

## A. Artificial Beach Nourishment

1. Concept. Artificial beach nourishment has not been extensively used in Hawaii. Because of this a number of technological aspects of the procedures will require further understanding before nourishment will see widespread use in the State. It is the goal of this report to briefly review some of the aspects and describe where further research is needed. Despite these weaknesses, beach nourishment provides an effective local option for reversing the trend of beach degradation.

Beaches can effectively dissipate wave energy, thus protecting the adjacent land from erosion. Because of this, the U.S. Army Corps of Engineers (COE, 1984) classifies them as a type of shore protection for adjacent uplands when they are maintained "at proper dimensions." Artificial beach nourishment accomplishes this with sand harvested from another source (borrow sediment, or fill) placed on the beach in such a way to widen the subaerial beach. This procedure, called beach restoration, is preferable to the construction of a seawall or revetment as a means of shoreline stabilization, provided funds are available, environmental impacts are minimized and there is sufficient interest in maintaining a recreational sandy beach environment (Noda, 1989; NOAA, 1990). Beach restoration enhances the recreational, and thus the economic, value of the shoreline. Restoration also increases public access and utilization of the coastal zone and its resources, and in many ways restores the former environment while protecting the adjacent upland from erosion. Extensive use of seawalls and revetments, as will be discussed in detail later, leads to beach degradation under conditions of long-term sea-level rise.

Beach restoration can be expensive. Large projects, such as the restoration of over 10 miles of Miami Beach, run into the many tens of millions of dollars (Miami: $64 million; Ocean City: $45 million). Smaller projects cost considerably less depending on many factors. On the U.S. east coast, it is common to nourish coastal segments less than 1 mile long for under $1 million. Many of Hawaii's beaches tend to be tied to restricted littoral cells with limited alongshore length, in many cases less than 1 mile long, so that costs could be lower on a per beach basis than for lengthy sandy coastlines. However this may be offset by cost increases associated with the lack of technological infrastructure to support restoration projects in Hawaii. For instance, there are no hydraulic dredging systems available in the State, and the cost for importation from the mainland will be considerable.

Preliminary estimates for nourishing Waikiki Beach from nearshore marine sand sources range from $12.50 per cubic yard to $24.50 per cubic yard (Noda, 1992). A total of 146,000 cubic yards of well-sorted, coarse white sand is needed to restore three target sites at Waikiki at a cost of $1.825 million to $3.577 million (Noda, 1992). Considering the economic value of Waikiki Beach, this is a very reasonable cost. As we shall discuss later in the case study at Kahala Beach, beach restoration can be performed in Hawaii with reasonable economy, and, once restored, beaches can be economically maintained under rising Hawaiian sea-levels.

The placement of sand on a beach does not in itself stop a long-term erosion trend (COE, 1984), and there are no guarantees that the newly restored beach will exist long enough to justify the cost. Newly placed sand can erode gradually, or be carried away in hours by a storm (NOAA, 1990).

Because the restored beach is likely to experience erosion, it will require periodic replenishment at a rate equal to or even exceeding the original erosion rate. In many cases the restored beach can erode more rapidly than the natural beach due to the loss of the fine-size component of the borrow sediment, and losses at the ends of the fill segment (Fig. 23). Erosion will be enhanced if the fill has a greater component of fine grains than the native sand. The fact that a nourished beach will erode leads to the need for establishing a schedule of periodic renourishment of the beach. Artificial beach nourishment may consist of stockpiling sand on the updrift end of a littoral cell that feeds the downdrift beach through the natural process of longshore transport. In most cases beaches are nourished along their entire length. Still other beaches may require several feeder sites with associated stabilizing structures.

A schedule of renourishment essentially sets the eroded beach "back in time" by establishing the configuration of the beach planform at some point earlier in the erosion history when the subaerial beach was wider. Existing theory supposes that if the nourished beach is designed with compatible sediment, and the geometry of the fill approximates that of the natural system, then storms, sea-level rise, and periods of high-wave energy will continue to erode the restored beach at rates equivalent to natural rates. If extensive losses occur at the ends of the nourished segment, or if the fill is not compatible, then higher erosion rates can occur.

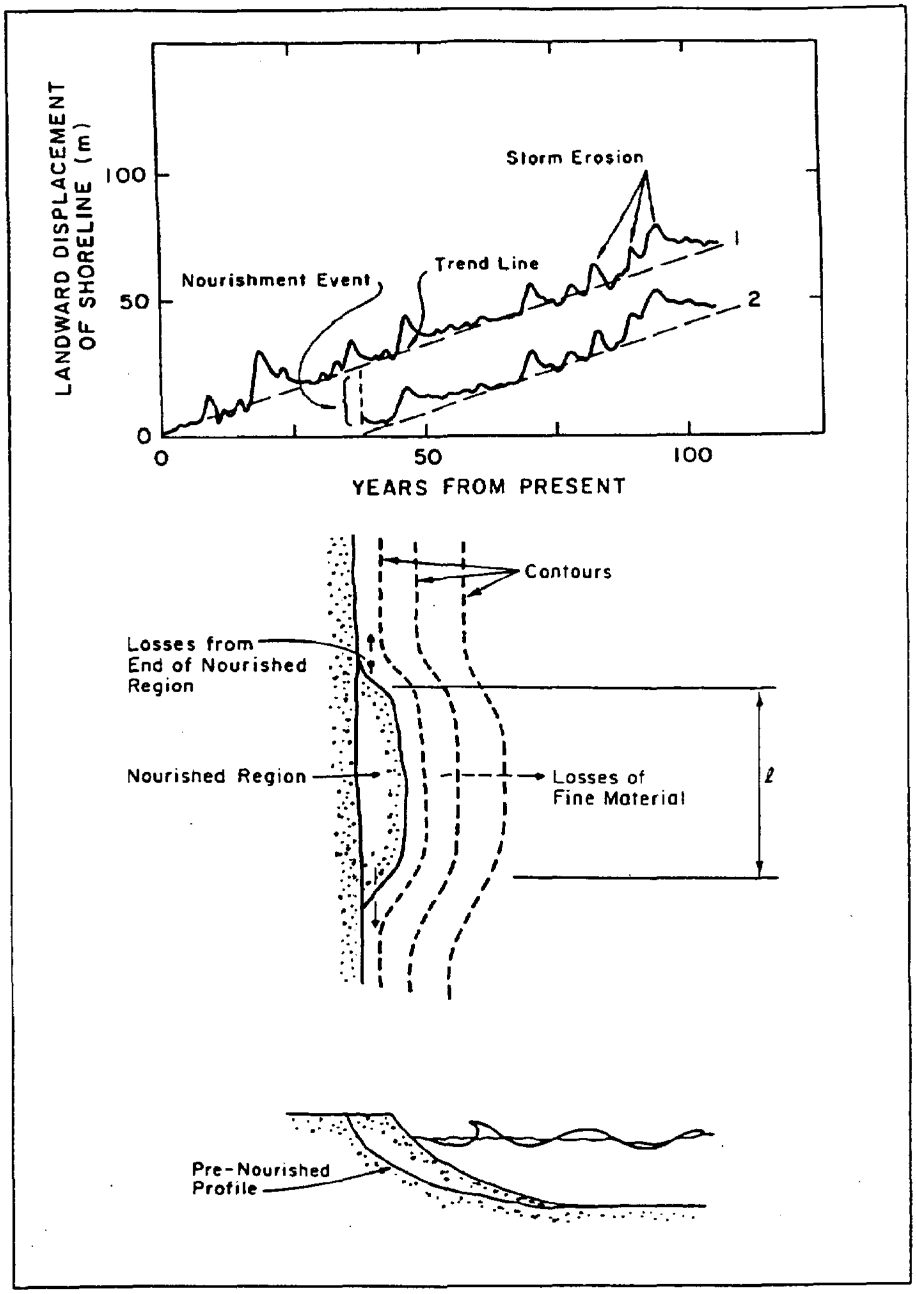


Figure 23. Erosion of a Nourished Beach. **TOP**: Line 1 is a depiction of the shoreline displacement history of a nonnourished beach. The trend line is the average, long-term erosion rate resulting mostly from sea-level rise. The irregular heavy line depicts erosional events (peaks) resulting from storms and high wave episodes, and beach accretion events (valleys) wherein the beach profile recovers following erosion. Line 2 depicts a nourished beach that theoretically should follow the same long-term and short-term history, only it is offset in a fashion consistent with the nourished beach width. The nourished beach is wider and therefore represents an earlier (less eroded) state. **MIDDLE**: A simplistic rendering of a nourished beach. Sediment is lost by offshore transport, and longshore erosion of the ends of the fill. **BOTTOM**: The nourished beach profile should be similar to the natural profile after a period of adjustment (Dean, 1983).

A controversial review of mainland replenishment projects concludes that the amount of fill, the frequency of renourishment, and therefore the lifetime cost of many projects is consistently underestimated (Pilkey, 1988). This report calls for reevaluation of the predictive capability of current renourishment theory, and warns communities contemplating nourishment projects that costs are tied to the frequency of renourishment which should be predicted on an actuarial basis rather than on existing theoretical grounds. The criticism levelled at present nourishment practices, cites frequent examples of over-optimistic predictions of beach-fill performance, and under-evaluation of the influence of storms on renourishment schedules and costs. As this discussion (Houston, 1991; Pilkey and Leonard, 1991) centers on mainland coastal systems, its direct applicability to island beaches is unknown. But these debates throw into question the level at which current understanding of beach processes and nourishment technology can accurately predict fill performance. They are cause for caution. Planning a nourishment project is not a rote exercise, and every consideration must be given to the factors governing success.

Sea-level rise causes beaches to move landward, potentially threatening fastlands that are developed. Beach nourishment is the only well-developed engineering technique that can counteract this recession and still maintain the recreational value of the beach. Nourishment is apparently a viable and successful response to the losses experienced by Hawaiian beaches, but there are numerous local factors that throw into question the validity of existing nourishment theory with regard to performance prediction and design criteria.

Some of these factors include seasonal changes in the wave climate that can alter the sand movement pattern, storms and particularly energetic wave conditions that can accelerate erosion rates. One intense storm can accelerate the erosion by decades. Another factor is that Hawaiian sand has unique characteristics, and these can control the slope of the beach, and the stability of the fill. In addition, nearshore circulation cells and permanent sand losses to offshore areas are related to reef morphology and the island wave climate. All these factors, and others, will determine the success or failure of any Hawaiian beach nourishment project. There are no guarantees that a properly nourished beach will survive to the designed life, but there are steps that can enhance the survivability of the beach and increase its recreational value. These steps come into play in several phases of the project: planning, sand selection, monitoring, and maintenance.

2. Planning. Establishing realistic design parameters for the fill is critical to the success of the economic and performance aspects of a nourishment project. All parameters of the fill project must be tuned to the direction and rate of longshore and cross-shore sediment transport, to the equilibrium beach profile (the natural geometry and slope) of the site, and to matching the granular characteristics of the fill to the native beach sand. This requires planning.

Sediment transport parameters can be supplied by a comparison of surveyed beach profiles from the site, and by a comprehensive littoral observation program recording characteristics of the wave and nearshore current regime. Surveys should be conducted at monthly intervals for at least one year, and preferably two or more years prior to the restoration project. The surveying should extend offshore as far as the active profile adjustment, which may be to the back-reef hardgrounds or an approximate depth of 30 to 40 ft (or approximately 0.6 mile offshore) if there is no reef. Thus the surveying will consist of a marine component requiring use of a boat, a high-resolution fathometer and a precision navigation system. While a comparison of historical aerial photographs of the site will provide estimates of the direction of transport, and the general rate of beach accretion or erosion, these will be averages of data spaced years, even decades apart. Only long-term, high-resolution beach profile survey data can supply the beach slope, the equilibrium beach profile to be anticipated when the fill equilibrates, and the specific annual rate of erosion that was acting on the natural beach and thus may be expected to act on the fill.

The equilibrium beach profile concept (Dean, 1983) idealizes natural variations in beach slope and sand characteristics under a steady wave field to describe an average beach profile. The concept is widely used because it is useful in predicting the final configuration of a fill segment after it has shifted its geometry to establish equilibrium with the ambient wave energy. In order to minimize offshore sediment transport, the geometry of the placed fill should approximate the equilibrium profile of the beach. An empirical description of the average profile of 502 mainland beaches on the Atlantic and Gulf coasts forms the basis for the theory (Dean, 1977). The theory, then, is derived primarily for quartz sand beaches under continental shelf-type wave fields. The technique employs a scale parameter that depends primarily on quartz grain size. The applicability of existing equilibrium profile theory in Hawaii should not be taken on assumption. The entire theory hinges on the behavior of sand grains in the water column and Hawaiian beach sand is substantially different from the quartz beaches forming the underpinning of the theory. It is likely that minor modifications to the theory would make it applicable to Hawaiian beaches, but the absence of a beach profile database for the State make this a nontrivial matter. The theory is empirically based, meaning that it relies on extensive field data. Also, although modifications to the theory may be minor, the impact of those changes may be significant in terms of the predictive ability of the technique.

Planning should incorporate a recognition that the restored beach will undergo an initial period of adjustment toward the natural equilibrium profile. Although the subaerial portion of the beach can decrease and the beach width narrow, sand relocated during this period of adjustment is thought to stay within the active beach zone (NRC, 1987). However, Hawaiian beaches tend to suffer permanent sand loss to large offshore feeder channels and sand fields, some of which cut through the reef and carry beach sand into deeper water. These sand channels and fields must be identified with a combination of field scuba investigations and aerial photography. The profile monitoring scheme should establish as one of its primary goals the extent to which local sand channels and reef morphology influence the beach erosion and accretion characteristics. The planform, and slope of the fill should be designed with a recognition of the morphology and location of offshore loss sites in order to minimize their influence.

An additional element of planning concerns adequate characterization of the seasonal wave climate and the occurrence of littoral sediment transport cells. These develop when waves construct complex nearshore current fields that control sand movement. Littoral cells can change on a seasonal basis as the wave approach direction shifts (Moberly and Chamberlain, 1964) and previously accreting sites can erode. A nourishment project should take seasonal sand transport trends into account in the planview design and slope of the fill. This is also a necessity in developing an accurate prediction of the fill performance, and renourishment schedule.

<u>3. Sand</u>. Sediment used to nourish a beach must match the physical characteristics of the native beach sand. It is common practice to assume that an average native grain size can be defined using samples of sediments from the active beach profile. Borrow sediments are deemed acceptable when the average fill grain size matches that of the beach to be nourished. However, a body of sediment typically consists of a more complex distribution of grain characteristics than can be effectively captured by an average particle size. Sediment grain characteristics

that influence the performance of the nourished beach include: grain geometry, fill sorting (grading), fill size skewness, grain mineralogy, and organic content.

Grain geometry, size, and lithology are determinants of grain fall velocity, which is the behavior of a sand grain suspended in the water column. Grains with high fall velocity tend to settle quickly to the bottom. Under a given wave and current energy, grains with high fall velocity are more resistant to erosion, thus enhancing the stability of the beach. In fact, the average fall velocity controls the geometry and slope of the beach (the equilibrium beach profile). If the fill fall velocity characteristics do not match the native sediment, then the equilibrium profile established by the restored beach can differ from the design, and from the native beach. A nourished beach with a low average fall velocity can erode faster than the native beach, shortening the life of the project.

One influence of fall velocity on the nourished beach is loss of fine sediments (low fall velocity) due to their instability under a given wave field. If a substantial portion of the fill sand has a low fall velocity, then this sediment will be placed into suspension and carried seaward to where the lower wave energy allows deposition to take place. The performance of such a nourishment project would be relatively poor, suffering from the loss of a significant percentage of the placed sand. It is possible to calculate an "overfill factor" (COE, 1984) which will predict the amount of fill that will be lost under this process, and plan for the loss by overfilling the nourished beach with a compensating volume. This, however, may not be an environmentally benign technique given the potentially huge turbidity cloud that could emanate from the beach and the light-dependent nature of coral reef communities. In Hawaii, given the fine micrite (calcareous mud) that is found in many offshore sand deposits, a nourished beach with a substantial overfill factor could potentially leach a turbidity plume for months to over a year and could be liable as a nonpoint-source pollutant.

Dean (1983) reports that if the fall time of suspended fine sediment is greater than the wave period, T, then that sediment will be carried seaward beyond the surf zone. Unstable beach grains with a fall velocity, w, will be suspended to some fraction, B, of the depth, h. For the criterion $[w < B\ (h/T)]$ these grains will erode from the beach and probably be carried in suspension seaward through the surf zone. At a suspension height Bh of 10 cm and a wave period of 10 sec, a grain with a fall velocity of less than 1 cm/sec would be eroded from the beach. For quartz sand this corresponds to a diameter of 0.1 mm, but for calcareous beach sand the size is unknown and the criterion is unquantified. Clearly, this would be a simple procedure and should be a required exercise in the planning phase of Hawaiian restoration projects for characterizing potential fill sediments. Olsen and Bodge (1991) have determined that aragonitic sand has a settling behavior equivalent to a quartz grain which is 1.36 times coarser. Because calcite has a specific gravity of 2.71, less than that of aragonite (2.95), the calcitic foraminifera that make up 80% of the carbonate beach sands in the State will behave like an equivalent quartz sphere somewhat less than 1.36 times coarser. Other components of carbonate sands here are aragonitic, and some are calcitic. The distribution of grain equivalent settling velocities in a fill candidate should be determined in order to assess fill performance under seasonal wave conditions.

Hawaiian beaches are composed of a variety of sand types, none of which is quartz, the dominant continental sand (Moberly et al., 1965). Little is known about the influence of carbonate (calcite and aragonite), heavy mineral, or basalt fragment sand grain fall velocities on beach equilibrium profile characteristics, or on the performance of restored beaches. Standard engineering procedures regarding this design parameter should be used cautiously on Hawaiian coasts as they are developed with the assumption that the sand is quartz (James, 1975).

The majority of restoration projects in Hawaii will involve carbonate sand, which, in the presence of acidic freshwater efflux, has a tendency to develop a cement matrix and form carbonate sandstone (or beachrock) (Fig. 24). Although not well understood, cementation seems to result from the percolation of acidic freshwater through the beach sand (from either rain or groundwater) causing solution and then deposition of a secondary carbonate matrix. Cementation may be accompanied by consolidation with the presence of a high silt fraction. The silt promotes tighter packing of the sediment giving the beach a hard unpleasant surface. Why some beaches form beachrock and others do not is not known. The restored beach at Fort DeRussy in Waikiki is known for its tight packing and hard surface. Ko Olina Resort near Barbers Point has artificial beaches that are both tightly packed and partially cemented. Little is known about the tendency for fill sediment to lithify, but the process is at least partially controlled by grain parameters (mineralogy, sorting, skewness) and pore water geochemistry.

Numerous documents (summarized in Dollar, 1979; Noda, 1991) report on Hawaiian sand resources, concluding that terrestrial reserves on Oahu are in the final stages of depletion, and that marine resources offer viable solutions to the

Figure 24. Beachrock. **TOP**: Cemented carbonate sands at Kahuku Beach, Oahu. This deposit formed at present mean sea level. The geometry, lithology, sorting, and bedding of the sands indicate that this is a former beach. **BOTTOM**: Three individuals stand on tabular beachrock at Mahie Pt. on the windward coast of Oahu. The recreational beach here has been lost due to stabilization. Sections of the former beach are preserved as beachrock in the intertidal zone, presumably they are sites of former freshwater efflux.

## Table 4: Summary of Oahu Sand Resources (Moberly et al., 1975)

| SOURCE | VOLUME (Millions of cubic yards**) | | QUALITY | | IMPACT* |
|---|---|---|---|---|---|
| | Total source | Likely to be useful | For component of concrete | For beach restoration | |
| COASTAL ZONE, OAHU | | | | | |
| Onshore | | | | | |
| Alluvium, colluvium, and glacial drift | 0.8 | 0 | poor to fair | very poor | slight to severe |
| Raised reefs (to be crushed) | 400 | 4 (?) | very poor | very poor | slight to medium |
| Lithified dunes (to be crushed) | 14 | 4 | very good | good | slight to severe |
| Inactive dunes and old beach ridges | 15 | 2.7 | fair to good | fair to very good | very slight to severe |
| Beaches above MLLW | 10.3 | 0 | fair to excellent | good to excellent | very severe |
| Offshore | | | | | |
| Beaches and other nearshore to 9 m (30') depth | 24 | 0 | fair to excellent | good to excellent | slight to severe but generally unknown |
| 9 m to 18 m (30' to 60') depth | 8 (?) | 4 (?) | unknown | unknown | slight |
| 18 m to 91 m (60' to 300') depth | 520 | 52 (?) | unknown | unknown | very slight |
| Dredged reef (to be crushed) | 4,100 | 20 (?) | poor | poor | very severe |
| INLAND OF THE COASTAL ZONE, OAHU | | | | | |
| Alluvium, colluvium, and glacial drift | 200 | 0.1 | poor | very poor | very slight to severe |
| Basalt (to be crushed) | 800,000 | 320+ | good | poor | slight to severe |
| IMPORTATION TO OAHU | | | | | |
| From Neighbor Islands (principal sources) | | | | | |
| Papohaku, Molokai | 3.2 | 0 | excellent | very good | slight, if careful |
| Mana, Kauai | 14.5 | 10 | fair to good | fair to very good | slight |
| Central Maui (to be crushed) | 640 | 200+ | very good | good | medium to severe |
| Penguin Bank | 350+ | 35 (?) | unknown | unknown | very slight |
| From Outside the State | | | | | |
| America | large | none | excellent | poor to fair | none to Hawaii |
| Australia | very large | some | excellent | poor to fair | none to Hawaii |
| New Zealand, Southeast Asia, etc. | very large | some | excellent | poor to fair | none to Hawaii |

*Probability of unfavorable impact on the natural environment due to exploitation of the sand
**1 cubic yard = 0.76 $m^3$ or about 1.3 tons

need for commercial sand (Fig. 25) (Moberly et al., 1975; Table 4). Research on offshore sands, conducted jointly by academic units at the University of Hawaii and private enterprise concerns with State and Federal funding (Dollar, 1979; Noda, 1991), has established that mining marine sands is economically and technologically feasible (COE, 1984). When conducted at carefully selected sites under rigid monitoring, marine sand mining can be environmentally benign (Maragos et al., 1977), although this is still an area of concern (Noda, 1991). Approximately 4 billion $yd^3$ of sand have been identified in waters less than 300 ft deep around the State. However, early successes in the Hawaiian sand mining industry never reached full commercial potential because of special interest groups (Dollar, 1979) and a complex array of regulatory obstacles. It is by special act of the Legislature that the mining related activities for Waikiki restoration are allowed.

Recent investigations at Waikiki (Noda, 1991) conclude that proximal marine sand reserves, dredged from offshore and hydraulically pumped through a pipeline onto the adjacent beach as a slurry, provide the least expensive and most logistically sound option for restoration. Ten sources of sand were compared, including commercial sand from Australia, Maui, crushed coral from Barbers Point, submarine deposits offshore of the Honolulu Airport Reef Runway, offshore of Waikiki, and deposits on the Penguin Bank offshore of Molokai. Although there are concerns regarding sand color, gradation and quantity, the prime candidates were deemed to be the shallow nearshore deposits at the Reef Runway and at Waikiki for a cost of \$12.50 to \$24.50/$yd^3$. Deep offshore sand deposits, or sand from outside the State are estimated to be considerably more expensive.

Cementation may affect the availability of offshore sand bodies for fill. Because some offshore sands are former beaches now drowned by sea-level movements, many of them have been exposed to acidic freshwaters. While there has been extensive geophysical research on the location, size and geometry of offshore sand bodies of Oahu and selected other Hawaiian sites (Moberly et al., 1975), few of these potential resources have been thoroughly sampled. It is uncertain which are unconsolidated sand and which are lithified beachrock. The sand source investigations for the Waikiki Beach restoration project (Noda, 1991) discovered that additional improvements are needed in both geophysical surveying and sampling techniques before offshore sand deposits can be adequately mapped for confident resource assessment. Attempts to physically sample offshore sands for Waikiki fill discovered that cementation and consolidation was extensive, predictions of grain size characteristics were frequently wrong, and the predicted

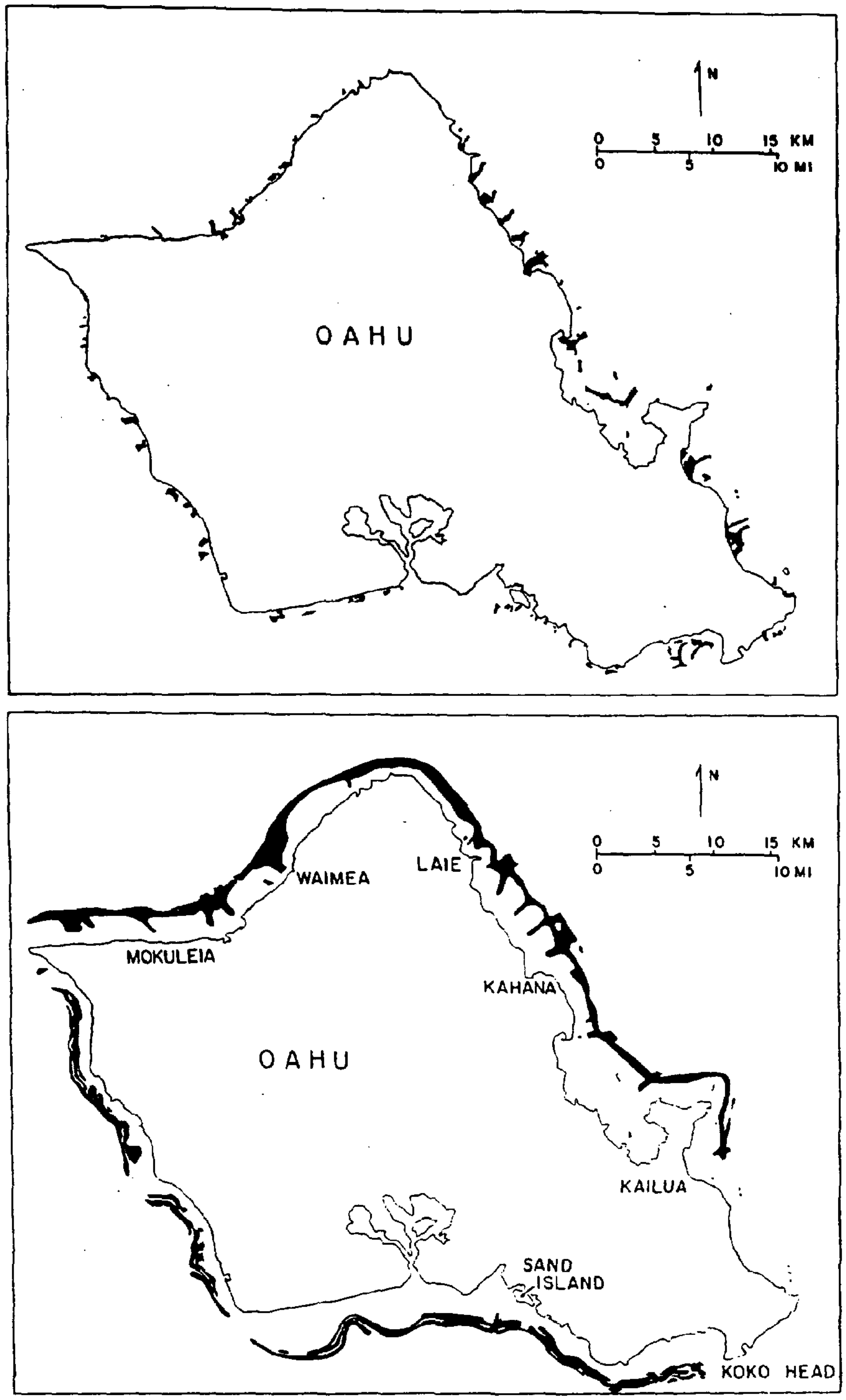


Figure 25. Offshore Sand Deposits. **TOP**: Marine sand bodies located between the present waterline and 60 ft water depth. **BOTTOM**: Deeper marine sand bodies between 60 ft and 300 ft water depth. The section between Kailua and Koko Head was not surveyed, and between Waimea and Laie surveys lack detail.

thickness of unconsolidated deposits was nearly always overestimated.

4. Monitoring. A crucial aspect of any beach restoration project is the need to monitor the performance of the fill, and the influence of the project on adjacent beaches and the adjacent reef. The practice of beach restoration is still an evolving science and many factors governing the success or failure of the project are as yet still undefined. We do not know, for instance, the influence of carbonate sand on beach geometry. We lack understanding of where beach sands end and offshore sands begin. Little to nothing is known regarding the influence of fill on reef communities in the proximity. What are the conditions of fill sorting and size skewness that lead to optimal performance, and how do we apply the parameter of grain fall velocity in best selecting high quality fill? What are the proper grain size and density criteria for a successful fill? How does a nourished beach affect adjacent beaches, and to what extent is offshore reef morphology a critical factor in fill performance? What are the influences of shoreline exposure and seasonal wave climates?

These and many other critical data on nourishment are best obtained through long-term profile monitoring and frequent bottom observations and sampling, at a high-resolution spatial and temporal scale. Early nourishment projects in the State will serve as models for latter ones. They will also provide data for defining many of the necessary parameters. The Corps of Engineers (COE, 1984) and numerous independent researchers (Dean, 1983) call for stricter monitoring programs to address these questions. Despite this, many nourishment projects go unmonitored, and the opportunity to obtain valuable data is lost. Hawaii has a chance to break new ground, and strengthen the chances for successful restoration by requiring clearly defined monitoring protocols with every nourishment project.

5. Maintenance. The need for periodic renourishment of the beach fill should be recognized by those responsible for funding the project. A longer-term commitment to the maintenance of the restored beach is an integral part of any restoration project. Procedures for calculating a renourishment schedule are provided in COE (1984), and discussed in Pilkey (1988) and Houston (1991). Regardless of the debate centered on the veracity of these projections, they are mainland projects and have little meaning in an island environment. Hawaii is on untested ground when it comes to predicting the life and performance of artificial beach nourishment.

The factors that will influence fill stability will change depending on the orientation of the coast, the season, the width of the reef platform that dissipates wave energy, and, of course, the granular characteristics of the fill. Beyond the influence of sea-level rise and seasonal/annual wave climate effects, the most important determinant of fill stability is storm frequency and intensity. Hurricanes affecting Hawaii (Fig. 26) produce a number of detrimental effects on beaches. High winds drive waves and pile water against the coast raising mean water levels as much as 5 ft. The low atmospheric pressure associated with hurricanes can cause the water surface to rise. If this is superimposed on a high tide and the surge generated by large waves, a beach can be completely drowned for several hours. The waves are not only higher, but the deeper water at the coast causes them to break closer to shore, carrying offshore sand resources beyond the recovery point of fairweather waves that restore the beach. The entire profile tends to shift down and sand is lost from the beach to compensate for the loss offshore. The result is a permanent reduction of beach volume, and severe beach erosion.

Storm erosion can be worsened if the back-beach region is structurally hardened. Seawalls and revetments will reflect the storm-wave energy during the period in which a beach is covered by high waters, enhancing the erosive power of the waves. For this reason, existing seawalls and high-angle exposed revetments should be removed prior to nourishing a beach. If not, the entire fill could suffer severe erosion in a drowning event such as a tsunami, a hurricane, or a tropical storm. Each of these meteorological or geophysical events can lead to reflected wave energy off existing structures. It is worth considering replacing protective structures with buried, low-angle (1:3) revetments as a means of protecting adjacent upland property over the short-term.

How often these events will hit Hawaiian coasts is a matter of speculation (see Bretschneider and Noda, 1985), but their occurrence governs fill life. A schedule of renourishment will have the rate of sea-level rise (discussed later) and landward recession rates as the primary pacemaker for the frequency of renourishment. The occurrence of hurricanes and tropical storms will interrupt this schedule at irregular, unpredictable intervals and require renourishment at higher frequencies than otherwise. Depending on the shoreline exposure, the interannual occurrence of particularly large north Pacific swell, southern swell, Kona storm waves, and northeast trade waves will also influence the renourishment schedule (Table 5).

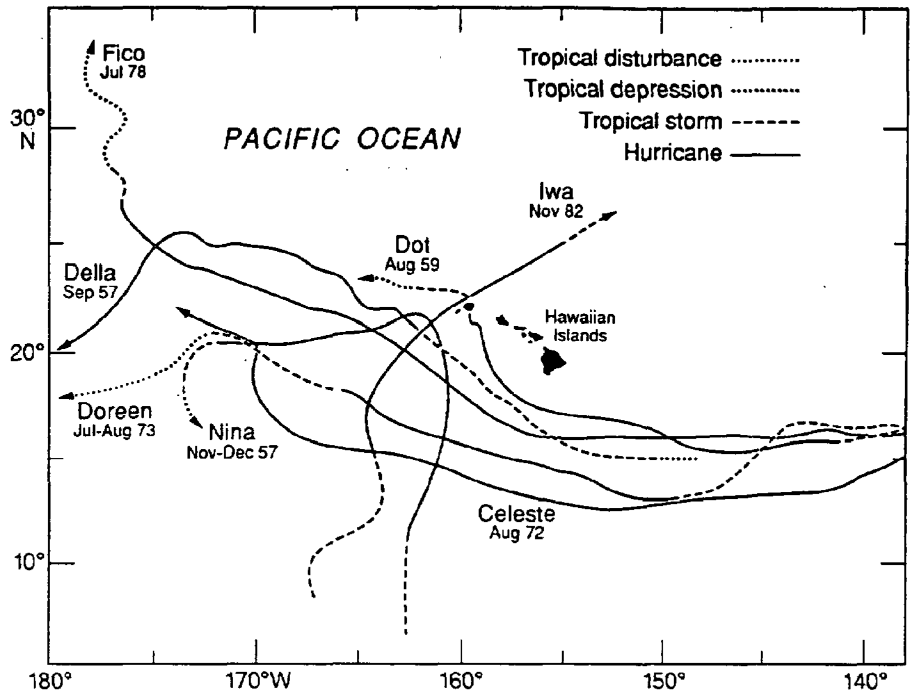


Figure 26. Hurricane Tracks. Hurricane storm tracks between 1957 and 1982 (after Noda, 1989).

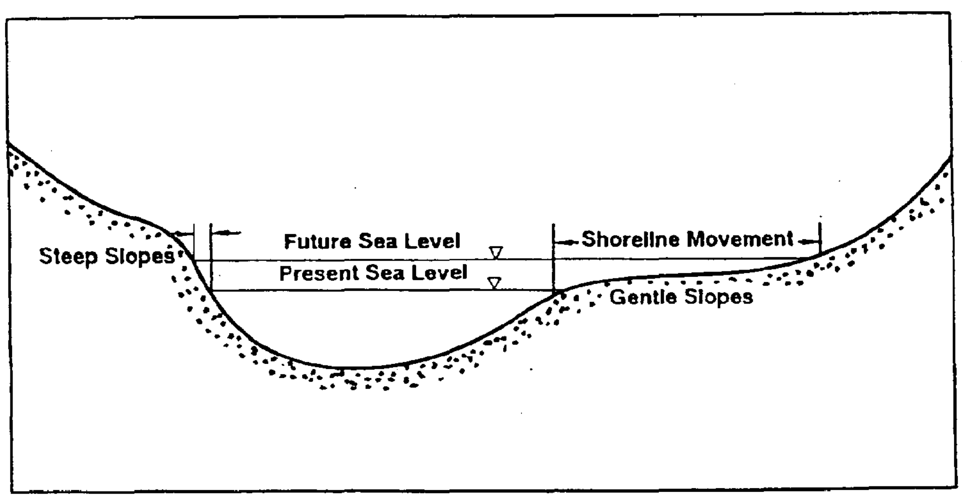


Figure 27. Coastal Inundation. The contour technique of determining coastal inundation due to sea-level rise (NRC, 1987), wherein shoreline movement and configuration depend on land slope. This method is only recommended for coasts with immobile substrates, such as basalt coasts.

Table 5 - Renourishment Frequency Factors.

| EVENT | EROSIVE POTENTIAL* | EFFECT ON MAINTENANCE FREQUENCY |
|---|---|---|
| Sea-level rise | High (not recoverable) | 5 Years to Decadal |
| Hurricanes | High (mostly not recoverable) | 5 Years to Decadal |
| Tropical Storms | High (partially recoverable) | 5 Years to Interannual |
| North Pacific Swell | Moderate (usually recoverable) | Interannual to Annual |
| Southern Swell | Moderate (usually recoverable) | Interannual to Annual |
| Kona Waves | Moderate (usually recoverable) | Interannual to Annual |
| Trade Waves | moderate/Low (mostly recoverable) | Interannual to Annual |

*recoverability: likelihood of subsequent fairweather waves to reconstruct a beach with offshore sand eroded by each event

<u>6. Effect of Sea Level Rise</u>. Sea-level rise leads to shoreline recession due to a combination of inundation and erosion. Part of the maintenance procedure is to project future shoreline configuration due to sea-level rise. A number of techniques exist for this, many of which are reviewed in Komar (1983), NRC (1987, 1990), and Pilkey and Davis (1987).

The contour technique (Kana et al., 1984) assumes that no planform alteration of the shoreline will accompany sea-level rise, thus a new shoreline is directly a product of passive flooding. Slope is the controlling variable (Fig. 27) and steep shorelines experience little flooding while gentle slopes undergo greater flooding as the inland excursion of the waterline is enhanced. This implies that the shoreline substrate is immobile, and that natural coastal processes are no longer active. It was under these assumptions that the report on the effects of sea-level rise in Honolulu was prepared (CZM, 1985). In Hawaii, these conditions will only apply on basalt coasts and should not be assumed for any sedimentary shoreline.

Another technique is the widely applied "Bruun Rule" (Bruun, 1962; NRC, 1987). The Bruun Rule is based on the equilibrium profile concept mentioned earlier, where a statistical average beachface geometry is assumed to represent a sandy profile at a particular water level. Dean (1977) investigated the quantitative expression for the profile proposed by Bruun ($h=Ax^{2/3}$; where h is water depth, x, is the horizontal distance from shore, and A is a constant for each profile) and found the expression was correct as an average for 502 quartz sand beach profiles on the mainland Atlantic and Gulf coasts. He also determined that the profile shape parameter A, was a function of grain stability under a given wave field (grain fall velocity). The Bruun Rule assumes that profile displacement in the landward direction is a direct function of sediment loss from the beach berm and beach face, and equivalent deposition on the offshore portion of the profile. Thus, shoreline recession due to sea-level rise takes place by the transfer of sediment from the beach to the adjacent offshore region. The shoreline adjusts landward by a given lost sand volume, and the offshore adjusts upward by the same volume (Fig. 28).

The Bruun Rule assumes that sea-level rise causes shoreline recession in all cases, and that the sediment volume lost from the beachface equals the sediment volume deposited offshore. Thus, the Bruun Rule suffers from several short-comings. The possibility of beach accretion is eliminated, permanent sediment losses due to suspension of finer sands are not considered, longshore influences are neglected, and the considerable effects of storms and high wave events are not treated. In addition, the requirement of offshore deposition does not allow for water deepening due to sea-level rise, which would otherwise tend to increase the incident wave energy and enhance beach erosion. Because of these inadequacies, an application of the Bruun Rule to determine the effect of sea-level rise on beaches provides only a partial description of the true probable impacts. Despite this, it is widely accepted and frequently used as a planning tool. The Bruun Rule relates shoreline recession, R, and sea-level rise, S, in the expression:

$$R = S\ [W/\ (h + B)] \qquad (1)$$

where W is the width of the active portion of the profile adjusting to sea-level change, h is the limiting depth of the active profile, and B is the beach berm

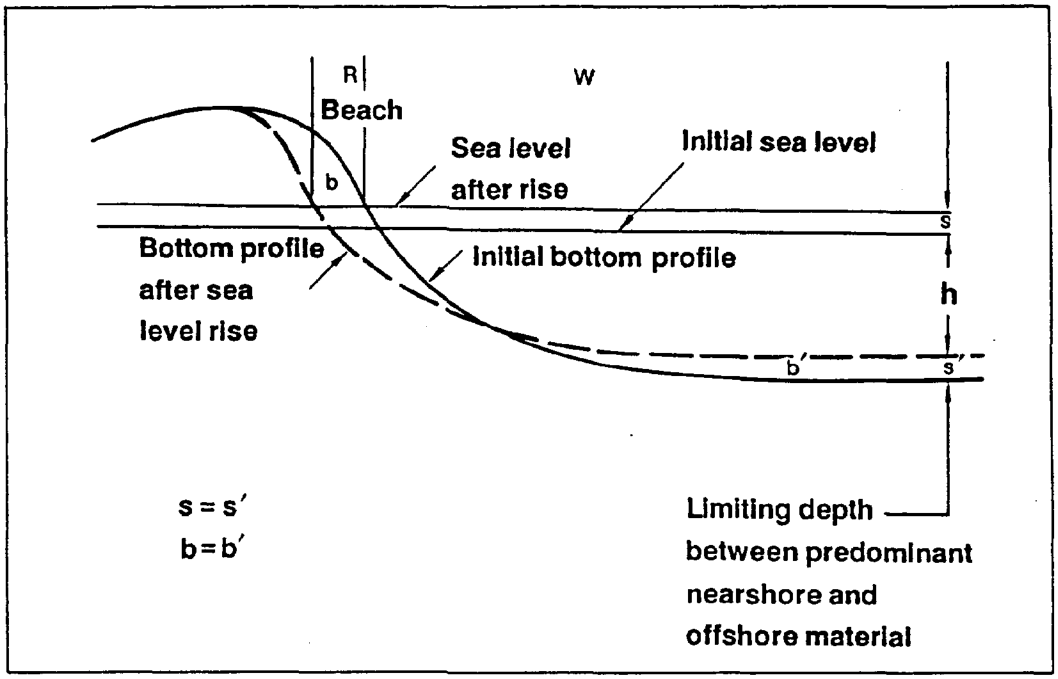


Figure 28. The Bruun Rule. The Bruun Rule relates shoreline displacement to sea-level rise by assuming that a volume of sediment eroded from the beach will be deposited immediately offshore without the loss of suspended material or the influence of longshore currents.

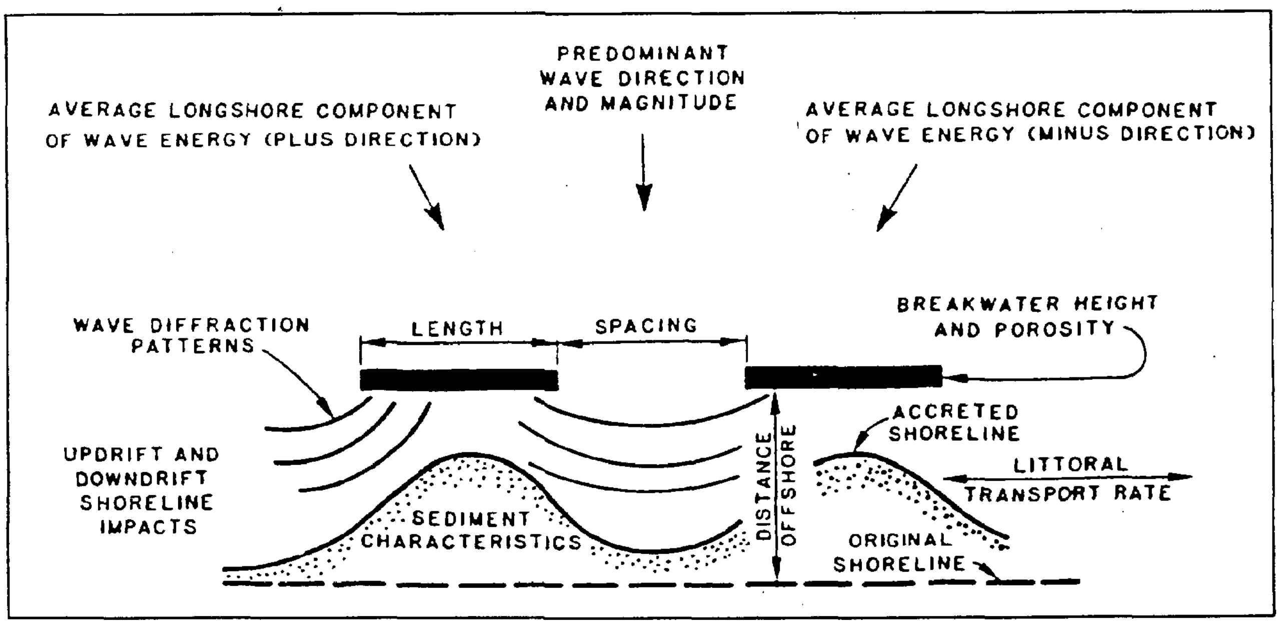


Figure 29. Plan-view of a Detached Breakwater. Design considerations for a segmented, detached breakwater (Pope, 1986).

height.

Applying the Bruun Rule for a typical Hawaiian shoreline, we can use the example of Waimanalo Beach on Oahu which has a berm height B of approximately 2 m (6.6 ft) and active sand movement h to a depth of 6 m (19.7 ft) (the reef depth). W can be estimated using A=0.1 $m^{1/3}$ (NRC, 1987) for the beach profile expression. Thus, the active portion of the profile adjusting to sea-level change is W= $(8/0.1)^{3/2}$ = 716 m (2349 ft). The recession rate multiplier in (1), W/(h+B), is 716/8=89.5. Using a rate of sea-level rise (S) of 0.62 in/dec. for Oahu (Chapter II-Table 3) yields an estimated beach recession rate of 4.6 ft/dec. under the present rate of sea-level rise. Under the projected submergence rates for next century (2.42 in/dec.: Chapter II) this increases to 18.0 ft/dec. (Table 6).

In Table 6, the known present-day rate of sea-level rise (column 2) is used with the Bruun Rule to predict the present-day rate of island-wide average beach recession (column 3). Comparing this to the average of measured eroding sites

Table 6 - Beach Recession Predicted Using The Bruun Rule

| Island | Present Sea-Level Rise<br><br>Tide Gauge Trend | Predicted Recession<br><br>Bruun Rule | Measured MOESE' 91<br><br>Aerial Photos | Projected Sea-Level<br><br>(IPCC, 1990) | Projected Recession<br><br>Bruun Rule |
|---|---|---|---|---|---|
| Hawaii | 1.55 in/dec. | 11.6 ft/dec. | 5.9 ft/dec. | 3.35 in/dec. | 25.0 ft/dec. |
| Maui | 0.97 in/dec. | 7.2 ft/dec. | 12.5 ft/dec. | 2.77 in/dec. | 20.7 ft/dec. |
| Oahu | 0.62 in/dec. | 4.6 ft/dec. | not avail. | 2.42 in/dec. | 18.0 ft/dec. |
| Kauai | 0.69 in/dec. | 5.2 ft/dec. | 5.9 ft/dec. | 2.49 in/dec. | 18.6 ft/dec. |

(MOESE, 1991; column 4) shows that predicted and measured recession rates are closely matched for Kauai. For Maui, the Bruun Rule underpredicts the measured recession rate, and for Hawaii it overpredicts the recession rate. The agreement for

Kauai may be fortuitous, and the disagreements are likely the result of local factors (i.e., extensive stabilization on Maui) and the lack of island-wide coverage for Hawaii in MOESE (1991).

Beach nourishment offers a means of effectively counteracting the recession caused by sea-level rise. To maintain a stable shoreline, the annual volumetric rate of nourishment, V, is equivalent to the annual rate of recession R, multiplied by the total vertical height of profile adjustment (h+B), so that

$$V = R\ (h+B) \qquad (2)$$

The volume of sand per unit shoreline length necessary to counteract beach recession due to sea-level rise, can be calculated for present-day rates of sea-level rise. This is performed using the Bruun Rule-predicted recession rates given in Table 6. The procedure is also useful for determining nourishment needs under future accelerated sea-level rise. This is done by employing the Bruun Rule-projected recession rates. These nourishment needs are readily converted into cost estimates assuming the price of sand used for the Waikiki Beach restoration project.

The Bruun Rule is the basis for the estimates in both Tables 6 and 7. Despite its deficiencies, it provides a means of making reasonable estimates of future beach recession trends and nourishment costs. For instance, to maintain a given beach width on a segment of shoreline 2,500 ft long will cost approximately $14,000 per year in renourishment expenses. If there were 25 properties on that coastal segment, the cost becomes an annual fee of approximately $560 per property. Considering Hawaiian beachfront land values, this is a minor fraction of the total property value. Expressed as an annual percentage of the property value, shoreline stabilization by beach nourishment becomes a reasonable cost of living on the coast.

Table 7 suggests that maintaining the roughly 65 miles of beach on Oahu in their present condition by nourishment under present rates of sea-level rise will cost approximately $1.9 million per year. For a five-year renourishment schedule the cost is $9.5 million every five years. Under accelerated rates next century, the annual cost will be $7.5 million and the associated five year renourishment cost $37.5 million.

Table 7 - Island Average Annual Beach Nourishment Requirements* per foot of beachfront

| Island | For present-day sea-level rise (in cubic yards/foot) | For projected sea-level rise (in cubic yards/foot) | Nourishment Costs/foot of beachfront Present Rise | Nourishment Costs/foot of beachfront Projected Rise |
|---|---|---|---|---|
| Hawaii | 1.12 | 2.43 | $14.00 | $30.37 |
| Maui | 0.70 | 2.01 | $8.75 | $25.13 |
| Oahu | 0.45 | 1.76 | $5.63 | $22.00 |
| Kauai | 0.51 | 1.79 | $6.39 | $22.37 |

* Assuming $12.50 per cubic yard

**B. Structures Commonly Associated With Nourishment.**

Because of the complexities inherent in the physical processes governing sand movement on the coast, it may be advantageous to alter the wave field and the nearshore current pattern with a strategically placed structure such as a detached breakwater, or a filled terminal groin. These should only be used in situations where the characteristics of the wave field are understood in detail, and where the structure of choice will clearly enhance the lifetime of the restoration project without compromising the integrity and vitality of adjacent coastal environments or posing a threat to the safety of those using the coastal zone.

1. Detached Breakwater. A detached breakwater can be an effective means of attenuating wave energy on the beach, creating a wave energy shadow zone (Fig. 29). Because longshore sand transport continues outside the lee of the breakwater, drifting sand brought into the shadow zone can be deposited, and localized beach accretion can occur. If the localized accretion extends beyond the trend of the adjacent coast, it is called a beach salient. If the accretion continues to the point that the salient attaches to the offshore breakwater, it is called a tombolo. The concept of a detached breakwater imitates the natural wave attenuating effect of an offshore reef, sandbar, or small nearshore island. Since the sheltered beach traps sand it has the potential to enhance erosion rates on downdrift beaches. For this reason the offshore breakwater should only be used in conjunction with a beach restoration project. In some situations a series of detached breakwaters can enhance fill performance. Optimal spacing and offshore distance of the

breakwaters is a function of seasonal wave energy and direction and can be calculated for a given coastal setting (Pope, 1986; COE, 1984).

2. Filled Terminal Groin. On a long reach of coast lacking discrete littoral cells, the lifetime of a restoration project can be enhanced by placing a low, short groin at the downdrift end of the nourished portion of beach. If properly designed, a filled terminal groin can stabilize the nourished volume yet still allow the normal longshore transport to occur. The groin should be buried in the initial placement phase of restoration, and it should be designed to allow sand to move both over its top (a weir groin) and past its offshore end in order to minimize downdrift erosional effects. Groins should only be used in conjunction with a restoration project where it can be demonstrated that future renourishment needs will be decreased by the structure, and where there will be no attendant downdrift erosion (Dean, 1983). Renourishment of the updrift beach should occur when the groin becomes exposed by erosion, and the beach downdrift of the groin is threatened with enhanced erosion by longshore sand blockage. Groins will not be appropriate in the majority of nourishment projects. Even the "leaky" groins we have described here have the potential to cause severe downdrift erosion. Filled terminal groins should only be considered in a nourishment project when the potential for negative downdrift effects is minimal, when cost considerations are attractive, when the need for future renourishment in decreased by the presence of the groin, and when continual monitoring and future renourishment are guaranteed.

3. Perched Beach. An additional option receiving interest lately is the perched beach. The perched beach raises the local profile with fill and an offshore submerged sill that inhibits seaward sand losses. The sill acts as a barrier to offshore movement of the sand transported as bedload in the hope that the profile slope is lessened, increasing the beach stability. It offers little discouragement to the suspended fraction, however and requires a downdrift filled terminal groin to limit longshore losses. Of concern is the obvious limiting effect the sill has on shoreward sand transport. Storm erosion would be permanent because the profile would not be allowed to recover unless by longshore inputs. Little is known about criteria such as appropriate depth and distance for the structure. Oversteepening of the fill beachface due to continual losses and little recovery may instead result from use of a perched beach. This may be a safety concern. Additional testing is required before this concept is attempted.

4. Buried, Low-Angle Revetments. The presence of seawalls or steep

revetments in the backshore area of a nourished beach can pose a threat to the stability of the fill by decreasing its performance characteristics during high energy, high water-level conditions. In the event that a nourished beach becomes inundated during a storm or hurricane (or tsunami), the enhanced energy reflection off the seawall will exacerbate the erosion resulting from the storm. Even a buried seawall is likely to become exposed in the course of the storm and act against the fill stability. Sand grains will stay suspended in the high velocity, turbulent floodwaters and will be transported offshore. It is preferable to destroy any upland stabilization structures prior to nourishment.

However, some landowners may express concern over a lack of fastland structural stabilization. In these cases a buried revetment (Fig. 30) at an angle no greater than 1:3 may be an acceptable alternative to a seawall or other high-angle structure. The revetment will armor the upland and, if adequately buried, will not pose as great a threat to fill stability. Features enhancing the benign influence of a buried revetment on the adjoining fill could be a rough and semi-permeable surface as a factor to enhance wave energy dissipation, and reduce reflection and backwash if the revetment is exposed in a storm. Burial should first be under packed and consolidated soil, followed possibly by sand from the nourishment project and heavy vegetation. Contingencies should be made for the repair, and reburial of the revetment if any action (including wave erosion) results in the exposure and deterioration of the structure. The structure should also be carefully monitored to determine its effect on fill stability under a range of conditions.

## C. Vertical Structures.

There is active discussion among coastal scientists regarding the influence of seawalls and revetments on the adjacent beach. However, there is a distinct lack of long-term field studies to provide an uncontroversial indication of whether shoreline hardening is a detrimental or benign agent under the influence of wave forces alone. A number of short-term studies (reviewed in Tait and Griggs, 1991) have investigated whether increased beach erosion and subaerial beach width reduction occurs along hardened shorelines (Fig. 31). The majority of these were inadequate in both spatial and temporal scope, and the data they provide is highly site specific and tied to particular events. No studies of seawall or revetment effects on Hawaiian shorelines exist.

Kraus (1988) reviewed the available body of literature on the potential

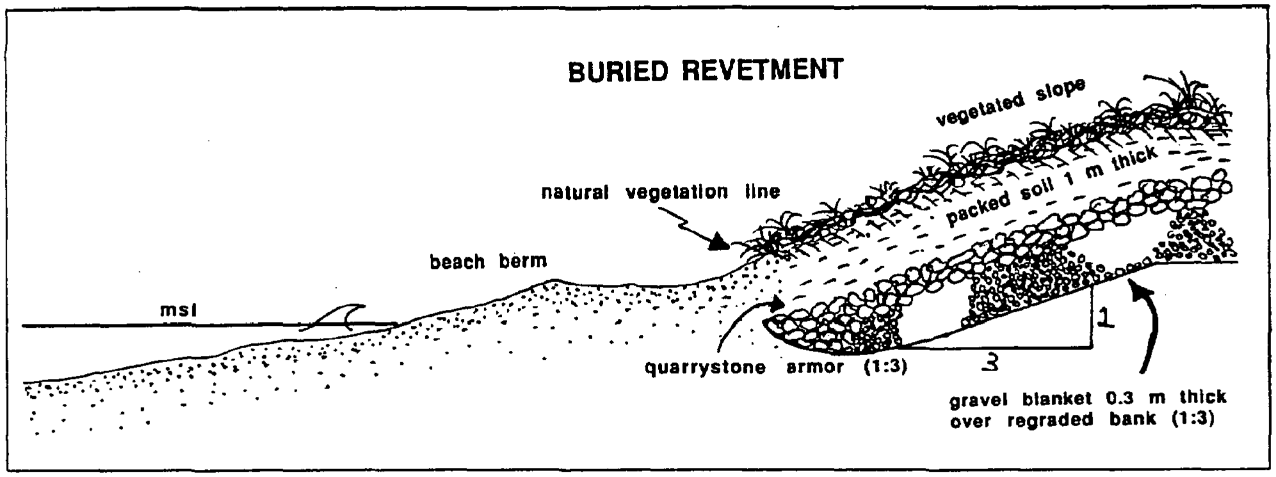


Figure 30. Buried Revetment. A low-angle buried revetment may be a short-term, benign method of upland protection for coasts where relocation is not possible. This should only be used in conjunction with beach nourishment, and where immediate repair and reburial is guaranteed if the structure is exposed. Unless future beach nourishment maintenance is guaranteed, long-term sea-level rise and shoreline recession will eventually require that this structure be removed or the adjacent beach will be lost.

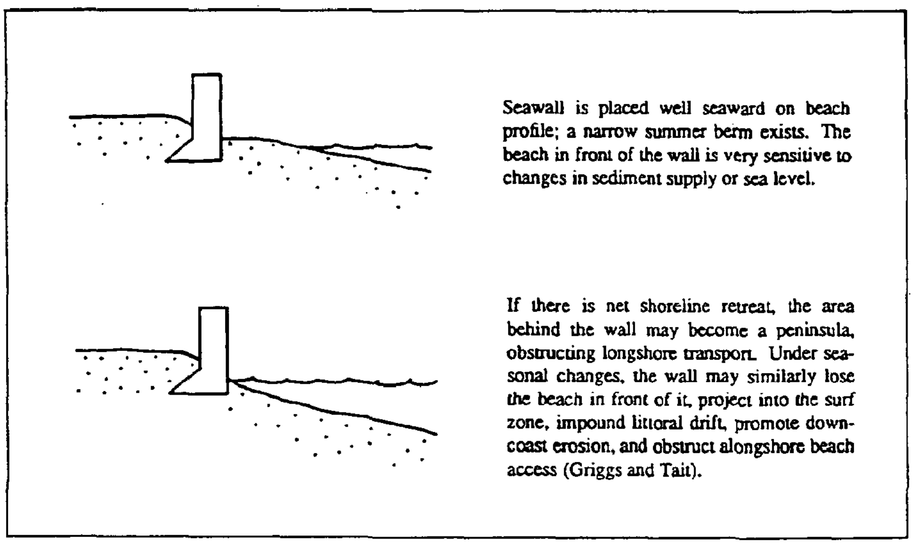


Figure 31. Seawalls. Long-term effect of seawall building on the beach profile (Tait and Griggs, 1991).

impacts of seawalls and revetments (Fig. 32). In the majority of cases, these studies examined the immediate, short-term effects of hardening related to storms and examined effects on a limited spatial scale. Kraus (1988) concluded that where adequate sediment supply exists, the beach is not detrimentally affected by hardening. But a beach with adequate sediment supply is either accreting or at least stable, and a seawall would not be built on such a beach near the waterline where it would interact with the run-up or active wave energy zone. Clearly, a stable or accreting beach will not provide evidence of the negative effects of seawalls and revetments because the seawall will not be built in the swash zone. Kraus also concludes that "on an eroding coast the beach in front of a seawall may narrow and eventually disappear if there is an inadequate sediment supply." An inadequate sediment supply is self-evident on an eroding beach. Thus, seawalls eventually lead to beach loss on eroding coasts.

In a regime of long-term sea-level rise, such as in Hawaii, all coasts will ultimately retreat landward. A seawall or revetment on a retreating beach will eventually begin to interact with, and reflect wave energy. As we have shown in Chapter II, a natural beach that is receding landward will maintain a consistent subaerial width and sand volume as it migrates landward. Such a beach will remain a viable recreational and environmental resource, provided the migration is not halted by hardening. In the presence of a landward structure, the landward border of a beach will cease moving at the base of the structure, but the seaward border will continue to migrate landward. With time, this leads to beach narrowing and sand loss exacerbated by a number of processes and morphological features observed by researchers. In a recent report by the U.S. Army Corps of Engineers (Tait and Griggs, 1991), all of the following effects have been observed in the field and attributed to the presence of seawalls and revetments (Fig. 33):

a. Wave Reflection: incident wave energy is dissipated on a natural beach, on armored coasts this energy is reflected, not dissipated. Numerous studies describe reflected waves moving sand seaward where it is removed by longshore currents.

b. Scour Trough: a linear trough or erosional depression fronting a seawall or revetment indicates sand loss from the toe of a structure, this often leads to structural failure by undermining.

c. Deflated Profile: the lowering or erosion of the beachface due to general sand loss along the entire profile fronting a structure occurs when waves interact with

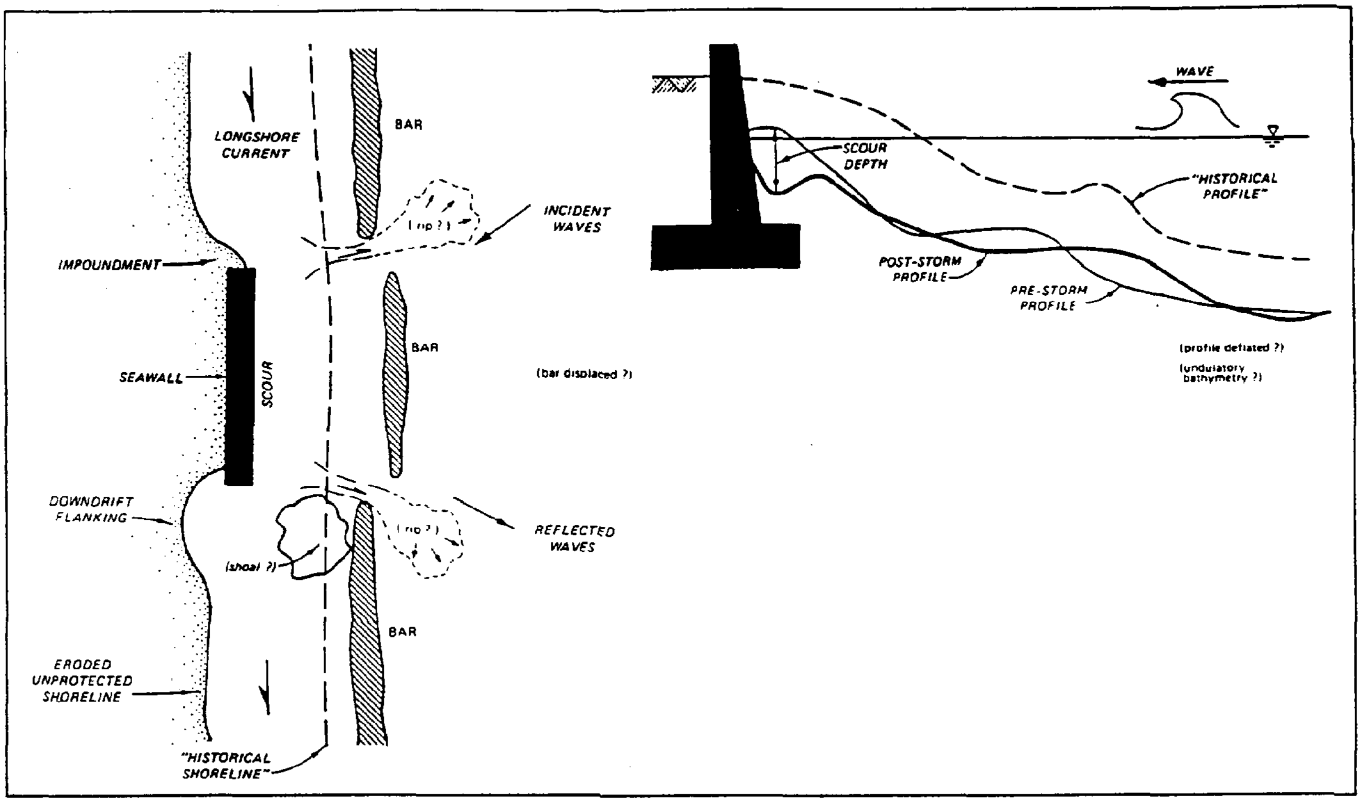


Figure 32. Seawall Impacts. Plan-view and profile view of seawall impacts (Kraus, 1988).

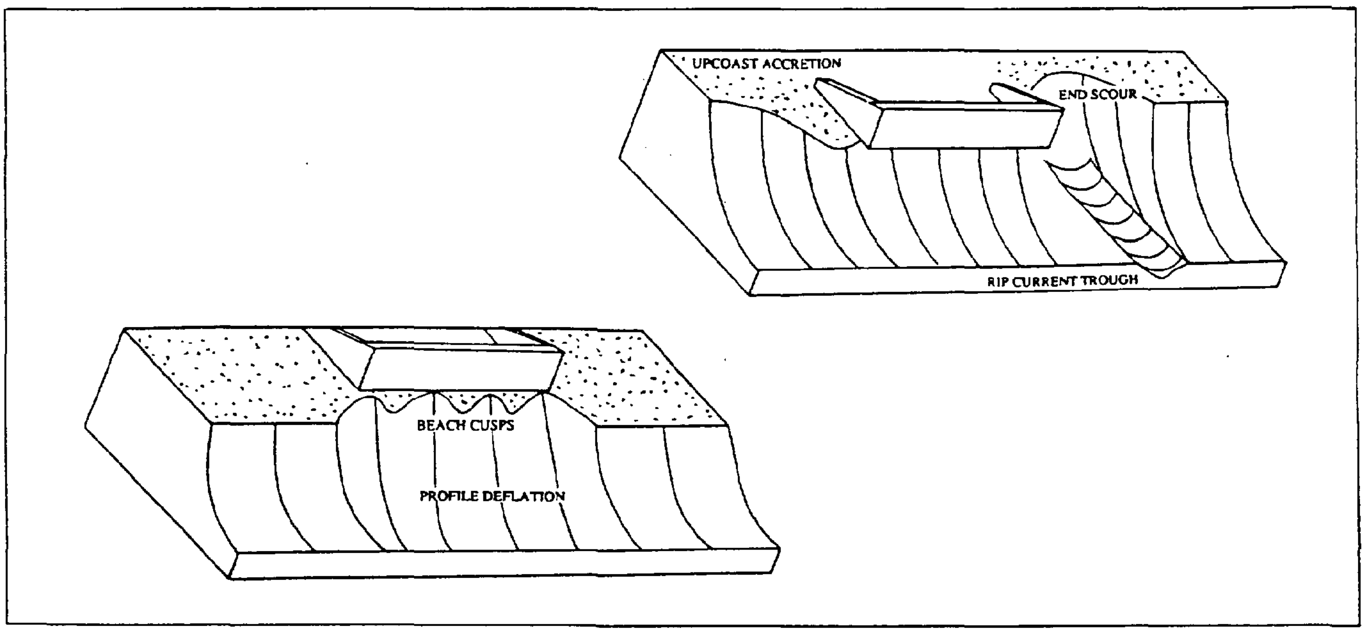


Figure 33. Beach Profile Impacts. Profile deflation, sand blockage, end scour, sediment loss (Tait and Griggs, 1991).

the armor unit.

d. Beach Cusps: crescentic or semi-circular erosional embayments on the beachface are associated with profile deflation and sand loss.

e. Rip Current Troughs: a trough or channel crossing through the surf zone has been observed to form in front of hardened coasts, this feature acts as a conduit for offshore sand loss.

f. End Scour: erosion of the unprotected beach adjacent to the end of a seawall (flanking) is associated with profile deflation, and often leads to structural failure.

g. Updrift Sand Impoundment: a seawall interrupting littoral drift can trap sand on the updrift end and lead to concomitant downdrift erosion and enhanced shoreline recession and beach loss.

h. Storm-Induced Scour: sand loss due to increased turbulence and wave reflection effects has been observed during high-water level and high-run-up periods associated with storms and seasonal wave climates.

i. Post-Erosional Recovery: shoreline hardening can impact the ability of a beach to recover lost sand following storm or seasonal erosion events, or longer-term cyclical erosion, leading to permanent sand depletion, and beach loss.

j. Higher Littoral Energy: increased longshore current velocities, and turbulence related to wave reflection, leading to higher sediment mobilization and sand loss offshore from a structure has been observed during storms and high wave periods.

k. Blocked Upland Sand Delivery: shoreline hardening prevents sand from moving to the beach form upland sources, such as the vegetated coastal dunes that are common on Hawaiian shores.

Tait and Griggs (1991) state that the overriding factor in the impact of a seawall on a beach is the long-term shoreline trend. If a shoreline exhibits an erosional trend, and some segment of that shoreline is fixed in position by a seawall, then the beach will eventually disappear in front of the wall (Fig. 34). On a stable shore, the wall will only affect the beach when storms, or seasonal fluctuations in the position of the shoreline, expose it to wave attack. Everts

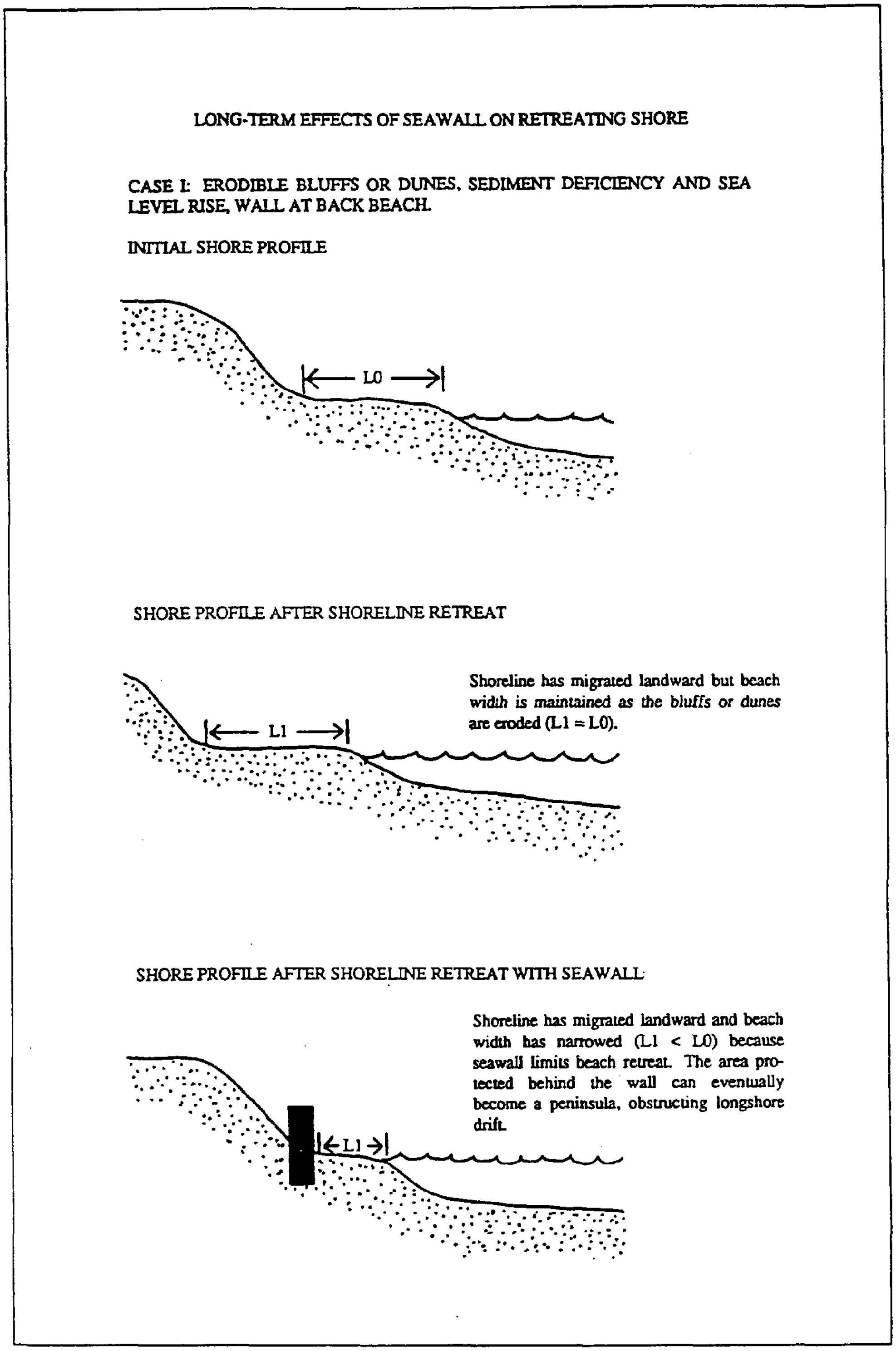


Figure 34. Seawalls. Long-term effects of a seawall (Tait and Griggs, 1991)

(1985) describes how armoring on a retreating coast, or one where fluctuations in beach width expose the armoring to waves, leads to sand scour and beach loss, and an increase in water depth and wave height at the shoreline.

Because it combines a thorough literature review with a relatively long field experiment, the study of Tait and Griggs (1991), funded by the U.S Army Corps of Engineers, is clearly the most comprehensive report on the problem of beach - seawall interaction. They find that the factors controlling the type and magnitude of beach response to hardening are numerous and interdependent. The variability of beach response and the apparent dependence on a number of interconnected factors requires that any evaluation of beach-seawall effects should be made on a site-specific basis. They also conclude that if net retreat is occurring, a condition that characterizes the Hawaiian coast, then "eventually the beach in front of a hardened shoreline will disappear. Such retreat is a function of a deficit in the littoral sediment budget and/or relative sea-level rise."

It is notable that what Pilkey in 1988 called the "Great Seawall Debate", has by 1990 become accepted as the Great Seawall Calamity. By this time, the detrimental effects of seawalls on beaches are widely accepted and form a basic assumption of nearly all local, State, and Federal offices and programs concerned with coastal zone management (with the exception of the Army Corps of Engineers). For instance, the N.O.A.A. Coastal Programs Division (1990) has taken a firm position against shoreline hardening:

*"A seawall on a beach not only accelerates beach erosion, but also inhibits the beaches ability to absorb storm energy, thus exposing structures (buildings) to the full force of wind and waves."*

*"Erosion control structures have the ironic effect of accelerating erosion, either in front of the development the structure is designed to protect, or downdrift."*

*"Although seawalls and bulkheads may stabilize an eroding shoreline for a time, normal and storm-wave action eventually strip away the beach in front of the structure and scour out its base, causing the wall or bulkhead to fail."*

*"Sound beach management requires that state and local governments limit or prohibit erosion control structures, particularly vertical structures such as*

*seawalls and bulkheads."*

There is little support, then, for the use of seawalls or exposed revetments as shoreline stabilization measures because they result in the loss of the adjoining beach and enhanced erosion on the adjacent coast.

**D. Restrictions on Shoreline Structures.**

Certain states, including Georgia, Maine, North Carolina and South Carolina, restrict by regulation the types of erosion control structures along the shoreline. In Georgia's Shore Assistance Act, the only type of shoreline stabilization allowed is with low sloping porous granite structures or other techniques which maximize the absorption of wave energy (Ga. Code. Ann. S12-5-238). In South Carolina, no new erosion control structures are allowed seaward of a 40-year setback except to protect a public highway (S.C. Code Ann. S 48-39-290). Existing erosion control structures may not be repaired or replaced if 80% of the structure is destroyed before June 30, 1995, 66% is destroyed between July 1, 1995 and June 30 2005; or more than 50% is destroyed after June 30, 2005.

As shown in Chapter II, and discussed in this Chapter, a major cause of beach loss around the islands is attributed to stabilization of the shoreline. Several previous studies have called for some restrictions on the use of vertical seawalls in certain areas (Sea Engineering, 1991). This report is in agreement with other studies which call for an investigation into the limitation on certain types of erosion control structures.

One option that should be considered is a restriction on future seawalls or revetments for large tracts of undeveloped land which have not been subdivided or zoned for urban use. Without the use of seawalls or revetments to harden the shoreline, landowners would need to plan natural beach instability into the design of a coastal project.

For existing coastal development where the shoreline is natural, effort should be made to utilize some soft approach, such as beach replenishment in conjunction with some other structural options suggested in this chapter. These options would require the formation of an improvement district.

Where it is not technically, legally, or financially possible to form an improvement district, shoreline stabilization devices such as gently sloping buried revetments placed landward of the certified shoreline should be the preferred erosion mitigation measure. These structures would reduce but <u>not eliminate the potential impacts on the sand beach</u>. Numerous coastal studies have suggested the use of buried erosion control structures to protect coastal property and minimize impacts on the beach (DHM inc., 1990; Edward K. Noda & Assoc. 1989). The Department of Land Utilization, City and County of Honolulu has required the construction of gently sloping revetments inland of the certified shoreline for four landowners at the southeast end of Lanikai Beach. The combination of the gentle slope of the new revetments, along with the removal of previous erosion barriers which protruded into the tidal zone resulted in the recovery of a lost beach. The gently sloping revetments at southeast Lanikai are alternately buried by sand and uncovered by erosion during the seasonal changes along this shoreline sector.

Regulatory restrictions on certain erosion control structures such as seawalls or bulkheads, could be placed at the State or county level. Alternatively, the restrictions can be imposed by the establishment of an overlay district with overlay regulation. There are many advantages to restricting seawalls and bulkheads by overlay regulation. These include the following: a) specific areas can be targeted that require special attention; b) opposition from overlay restrictions may be less than if similar controls were placed at the State or county level, since a smaller group of landowners would be affected; and c) the counties may take the initiative to establish regulatory restrictions, should the State fail to act. The disadvantages of relying on overlay regulations to restrict seawalls or bulkheads is that: a) it fails to provide a comprehensive solution to the pervasive problem associated with beach loss and sea-level rise and b) it abdicates protection of the State beach resource to the counties.

# VII. FUNDING

One of the critical issues for any beach management district is who should pay for the costs. The public may want the landowner to pay since it can legitimately be claimed that the coastal homeowners create the need for less harmful erosion control protection (see Figs. 2 through 6). The landowner may want the State or county to pick up the tab since a beach management project benefits all the public. The county would want the State to pay since the beach is state land. The state may want the county to pay since the county can prevent many beach erosion problems through their land use policies.

Many coastal states have grappled with the issue of funding in the administration of beach management districts. The common theme for the majority of districts is that there is a shared cost system with contributions from the government and the homeowner. For example, in California, if Federal funds can be obtained to pay for half of a project for beach erosion control, then it is the policy of the State to split the remaining cost with the local government. In Connecticut, beach erosion control projects that benefit the private littoral owners are paid for in equal shares by the State, the local government and the coastal landowner (Conn. Gen. Stat. Ann., Title 25-Water Resources, S 25-71). In Florida, State initiated programs of beach replenishment are paid with 75% of the cost from the State and the remainder from the local government (Fla. Stat. Ann. S 161.101). Money for the preliminary design and other costs of the project is derived from the Florida Beach Management Trust Fund. In Maryland, the State payment for a nonstructural erosion control project may not exceed 50% of nonfederal cost (Md. Nat. Res. Code Ann. S 8-1007). In North Carolina, private landholders may petition the State for grants that cover 75% of the cost of shore protection in the instance where public access is allowed and provided for (N. C. Stat. S 143-215.71).

For Hawaii, a shared cost system is proposed. This chapter discusses different sources of funding. After the discussion of funding sources, some suggestions are offered about the allocation of costs within a Beach Management District.

## A. Sources of Funding

<u>1. Federal.</u> One source of Federal assistance that should be investigated by

the State is appropriations under the River and Harbors Act (33 U.S.C.A. S 401 et seq.). Specifically, section 426e of the Act provides for Federal aid in the protection of shorelines. The Federal contribution for an erosion control project is not to exceed one-half of the total cost of the project. Thus, there is the requirement that the State or local government share in the funding of the project.

There are also provisions in the Act that allow shores other than public to be eligible for Federal assistance, if there is a public benefit such as that arising from public use. The Federal contribution is to be adjusted according to the degree of public benefit. One state that has taken advantage of this Federal program is Florida. Numerous beach restoration projects have been funded with Federal aid. Many of the projects include long stretches of shoreline that are backed by private hotels. As long as the project has some public benefit, such as access to the beach and use by the public, then the project may be eligible for Federal assistance (John Housley, pers. comm., Army Corps of Engineers, Planning Division, Washington, D.C.).

Under section 426g of the Act, the Secretary may authorize small shore and beach restoration and protection projects, provided that not more than two million dollars is allotted for any single project. Federal assistance under the River and Harbors Act could play a major role in the formation and financing of Beach Management Districts.

In the future, the State may have to establish, or be committed to, a beachfront management program to be eligible for Federal assistance. Congress is to consider the requirements that the State have guidelines for shoreline setbacks based on a 30 year annual erosion rate, restrictions on erosion control structures, and provisions for relocation before federal assistance is received (33 U.S.C.A. 426e) . These topics are covered in other chapters of this report.

Another source of Federal funding that should be investigated by the State includes the use of erosion benefit payments under the Upton-Jones amendment to the National Flood Insurance program. Certain coastal homeowners who are covered under the national flood insurance program and threatened by erosion may receive up to 110% of the value of their structure if they relocate inland or demolish their structure. To receive the benefits, homeowners must be in a zone of imminent collapse. There are other qualifications that are required to benefit from this program that are discussed in Chapter VIII. Although benefit payments under Upton-Jones would not be used in the formation of a Beach Management District, this program could provide important financial relief to coastal landowners who are endangered by erosion.

2. State. Many of the proposals outlined in this report are structured to reduce the financial burden on the State. For example, there are suggestions to seek Federal funding and to recover costs from landowners in proportion to benefits imparted on their property through the establishment of improvement districts. Nevertheless, a long-term commitment to beach preservation by the State will require increased effort in the form of new programs and financial support. As the trustee and caretaker of the coastal resource, the State should play the major role, both financially and administratively.

A State that has made great effort to save its beach resource is Florida. Florida is heavily reliant on its tourism industry and has made a real commitment to beach preservation. Between 1965 and 1984, approximately 115 million dollars were spent in the State on beach recovery techniques, primarily sand renourishment (National Research Council, 1987). Given the high cost of real estate and the high tourist revenues, it was easy to justify the projects on a cost-benefit ratio.

In Hawaii, it is improbable to expect levels of funding similar to those in Florida. Nevertheless, it is not unrealistic to expect a continuous source of revenue from the State to pay for beach preservation programs. To allow continued loss of beaches in a State where tourism is the number one industry will wind up costing the State more in the long-term.

3. County. It is anticipated that counties will pay a small portion of the cost for any beach improvement district. The counties should be made to pay at least a token amount for two reasons. First, in the apportionment of cost for improvement districts, allocation schemes are based on the amount of benefit conferred. For an improvement district within a particular county, say for example in Maui, it would be the residents of Maui who would benefit more than residents outside the county. A second reason why the counties should pay a small amount is that the counties may, through their land-use policies, prevent erosion problems in undeveloped areas by planning for coastal erosion. If the counties were made to pay for beach improvement districts, it would provide economic incentive for the counties to plan for coastal erosion.

4. Assessments. Benefits from any public improvement can be classified as general or specific. General benefits are those that accrue to the public at large. Specific benefits accrue to a particular group of individuals. Using beach renourishment as an example, one benefit from a wider beach would be improved lateral beach access and increased recreational utility. These benefits are general since they accrue to all beach users, regardless of whether they lived next to the beach or many miles away. Another benefit from sand replenishment is that a wider beach absorbs wave energy, thereby reducing the threat on adjacent land from wave inundation and erosion. Furthermore, a beachfront home is likely to increase in value if there is a wide, healthy beach in front that provides recreational opportunities and some protection from the forces of nature. Shoreline protection and increased value of the property are specific benefits since they accrue only to homeowners who live along the shoreline.

Landowners who abut the beach would be major beneficiaries of a sand replenishment project. In such a case, the landowner would receive general and specific benefits. The theory behind an improvement district is that the landowner is assessed a fee in proportion to the specific benefit conferred on the property. Therefore, for any improvement project within a beach management district, a special assessment for those landowners who live along the shoreline should be made.

There are many assessment formulas that can be used, such as the linear footage along the beach, the area of land benefited by the project, the value of the land next to the beach, the distance of structures from the shoreline, or a combination of the above factors. A common method to apportion an assessment is based on the front footage of the land (Md. Nat. Res. Code Ann. S 8-1007). Since the amount of protection from an erosion control structure or beach replenishment project is proportional to the length of shoreline protected, linear footage along the shoreline is a logical factor to consider in an assessment. In addition, the cost of an erosion control structure or sand replenishment project is proportional to its length along the shoreline.

Another alternative would be to base the landowner assessment on more than one factor, say for example, length along the beach and value of the property. By using value of the property, some consideration could be given to the individual landowner's ability to pay. A proposed Division of State Beaches could work up the specific criteria and formulas for the equitable assessment of the landowner.

A few points should be made about landowner assessments within the context of the beach management district:

a) In any improvement district regulation, provisions need to be made for maintenance assessments. This is especially important for a sand replenishment project where periodic renourishment is required.

b) In an improvement district, assessment charges are either payable when due or in annual installments over a period of 10 to 25 years (See e.g., Md. Nat. Res. Code Ann. S 8-1006; N. C. Gen. Stat. S 153A-200; Revised Ordinances of Honolulu, Chapter 24, Sec. 24-3.2). To encourage landowner participation in a BMD, a program similar to that in Maryland should be considered whereby low interest or no interest loans are offered in the installment payment plan.

c) There is the legal requirement that money from assessments in an improvement district must be used to pay for improvements in that district. Therefore, it is suggested that assessments collected be held in a Special Assessment Trust Fund until they are ready to be used.

d) There is a strong incentive for the coastal landowner to participate financially in a beach management district. For many beach sections, seawalls are being undermined by constant wave action. As sea level continues to rise and protective beaches disappear, the cost to maintain these structures will increase. Homeowners need other alternatives to protect their properties. It is through an improvement district, where landowners share the cost with the State and county, that other options to provide long-term protection may be developed.

5. Tax Incentives, Credits and Fees. The primary purpose of taxation is to raise revenues. However, tax programs and tax policy can also shape investment decisions, which in turn, may affect development and land-use policy. From a political viewpoint, the use of the word "tax" has a strong negative connotation. However, innovative tax programs can be implemented which actually favor the State, the public and the landowner. In fact, one of the tax programs was initially suggested by a beachfront homeowner.

In this study, two tax programs are discussed that could lead to improved beach management and significant revenues to the State. These programs are offered not as recommendations, but as options the State may or may not pursue. These programs, as well as others that provide economic incentives and disincentives, should be investigated by the State as a means to raise revenue for beach preservation projects. Each of these programs would require more study than can be devoted to the topic in this report.

a. Tax Deductions. Two broad generalizations can be made about beachfront homeowners. First, given the cost of beachfront property, many of the homeowners are likely to be affluent. While no study was made to verify their personal background, it is probable that many are professionals, who are familiar with the use of tax shelters and deductions. An exception to this generalization may be the case where there has been long-term family ownership of property, and ownership has been transferred by inheritance.

Another generalization is that beachfront homeowners will go through great efforts to protect private property from coastal erosion. As discussed in previous chapters, the demand to protect coastal property is expected to increase because of rising sea-level.

Based these generalizations, the State can tailor tax policy to increase the level of funding by the coastal landowner for the capital improvements within a BMD. For example, a State tax deduction could be offered to beachfront homeowners who contribute more than their assessed amount to pay for the capital improvements in a BMD. The assessed amount is determined by an allocation formula (see next section).

The State and county would benefit from the tax deduction since the increased contribution by the landowner may offset some of their cost for the district improvements. The landowner would benefit since they are allowed a tax deduction for improvement projects that protect their property. The public would benefit because a public beach may be preserved or restored at minimum cost to the State.

b. The Shoreline Property Transfer Tax. There is one major problem in funding beach preservation programs. Coastal properties have risen astronomically in price. At the same time, State and county budgets are squeezed just to pay for basic public services. As coastal properties escalate in price, it becomes prohibitively expensive for the government to finance programs for the acquisition of rights-of-way or to develop a voluntary relocation program that features the purchase of the underlying land. One way to alleviate this problem is to link the cost of coastal property with the revenues for funding beach preservation programs. This could be done with a small tax for the transfer of beachfront property.

The property transfer tax has been successful in buying open space in Massachusetts (Steve Blivens, pers. comm., Massachusetts Coastal Zone Management Program). For the islands of Martha's Vineyard and Nantucket, a 2% transfer tax is placed on all property transfers. All houses on these islands are in the coastal zone. Revenues from the taxes are placed in a special fund that is used to buy open space along the coast. A significant amount of open space has been purchased through this program.

There have been attempts in Massachusetts to extend the transfer tax beyond Martha's Vineyard and Nantucket. Opposition to the tax comes from the real estate lobby, which has argued that the transfer tax drives home prices down. For Martha's Vineyard and Nantucket this price effect is not apparent as most houses have risen gradually in price since the tax went into effect. This is an indication that market factors are the controlling factor in the price of property rather than the small 2% transfer tax.

If a shoreline transfer tax was implemented in Hawaii, one concern may be the potential impact on home prices. Some interest groups may argue that the tax will have a rippling effect that causes rising home prices throughout the State. Conversely, the real estate industry and landowners would argue that such a tax drives property prices down. Additional study would be needed to predict the exact impact on home prices, or to formulate strategies to mitigate the problem. Nevertheless, the experience from Massachusetts indicates that general market trends related to the economic business cycle will ultimately control the price of real estate.

Other jurisdictions across the country have modeled their land acquisition programs after Nantucket's. Two new programs may soon be set up in Hilton Head, South Carolina and the State of Washington.

The State of Florida also has a property transfer tax that is based on the use of documentary stamps. When the deed to a property is transferred, a stamp of the document is required to record the deed. The cost of the documentary stamp is based on a percentage of the sales price of the property. Assessments from the transfer tax are used to acquire land, or build low income housing projects (Kirby Green, pers. comm. - Florida Division of Beaches and Shores).

For Hawaii, a property transfer tax should be investigated to help finance the following:

1) capital improvements within a Beach Management District

2) a program of open space coastal land acquisition

3) a voluntary relocation program where State funds are coupled with the FEMA Flood Insurance relocation money to provide economic incentive to move threatened structures inland.

The shoreline property transfer tax is an option that the State should investigate as a means to raise money for beach preservation programs. Such a tax is believed to be a fair and non-burdensome request of the beachfront owner for the following reasons:

1) The long-term homeowner could view the transfer tax as favorable. In return for a minor transaction fee when the property is sold, the beachfront owner may be able to benefit from two programs. First, a voluntary relocation program could be developed whereby funds from the transfer tax along with Federal funds from the Federal Flood Insurance program are combined to provide, under certain conditions, a form of insurance during erosion or storm events. Another program that may benefit the landowner is that at appropriate localities, the homeowner may be able to benefit from the capital improvements within a Beach Management District. These capital improvements could be financed, in part, with the transfer tax. Thus, the transfer tax should not be viewed as a penalty on the beachfront landowner. The tax will be used to pay for programs that benefit the State, county, public and the private landowner.

2) In its natural state a receding beach does not wash away but simply shifts inland (see, e.g., Fig. 2; see generally, Gilbert, 1986). Only after the shoreline is hardened or stabilized is the beach likely to disappear. Hardening of the shoreline is not required until a man-made structure is threatened by erosion. In a sense, the

coastal landowner creates the need for expensive erosion mitigation alternatives that do not harm the beach. A shoreline tax would help pay for these alternatives.

3) The transfer tax for properties abutting the shoreline is not a burden for long-term homeowners who plan to stay in their residences. The transfer tax may affect the practice of short-term ownership and speculative purchases of shoreline property.

4) It is only when the property is sold that a small fraction of the benefits of living along the coast are recovered for the public. It may be questioned why any benefit should be recovered for the public. A strong argument is that for beaches that have disappeared or have been impacted by stabilization, private use of the shoreline has resulted in a lost public benefit. Revenues from the transfer fee can be used to recover some of the lost public benefit at the locality where the property was sold, or at another suitable site.

5) It is because shorefront properties are so expensive that a voluntary program by the State to acquire coastal land, relocate structures, and remove seawalls would be difficult to finance without significant contributions from outside sources. Thus, the transfer tax is suggested in this report. The transfer tax is powerful since revenues from the tax rise as shoreline properties rise in value. In addition, revenues from the fee are derived whenever a beachfront property is sold, thereby insuring a steady and significant source of revenue is available for programs that preserve the beach and protect the shoreline property owner. Finally, a permanent small fee can raise a large sum of money (See example below).

In order to meet Constitutional requirements, land should be taxed uniformly and at fair market value (Hagman & Juergensmeyer, 1986). If a beach property transfer fee is established, it should be structured similarly to the one in Massachusetts, where the tax rate is a uniform 2% for all applicable properties, based on fair market value.

Another alternative to the flat tax rate of 2% would be a graduated tax rate that allows a lower rate for those who are less able to afford the tax. For example, a rate structure may be based on the sale price of a home, according to the following schedule:

| | | |
|---|---|---|
| $0 - $350,000 | - 0% | (no taxation) |
| $350,000 - $500,000 | - .5% | |
| $500,000 - $1,000,000 | - 1.0% | |
| $1,000,000 - $1,500,000 | - 1.5% | |
| $1,500,000 - $2,000,000 | - 2.0% | |
| $2,000,000 - $2,500,000 | - 2.5% | |
| $2,500,000 - $3,000,000 | - 3.0% | |
| $3,000,000 - $3,500,000 | - 3.5% | |
| over $3,500,000 | - 4.0% | |

It should be noted that for houses under $350,000 (the approximate median price for a house in Honolulu) there would is no tax imposed. Whether there is a graduated tax as shown above, or a uniform 2% transfer fee as in Massachusetts, it is suggested that the $350,000 exemption be considered for the sake of fairness.

In order to make the transfer tax politically acceptable, the tax could be linked with a program where landowners are eligible for reduced property evaluations if they conduct activities which preserve or protect the beach. For example, if a landowner has not armored the beach, or if the beach has been stabilized but all permits are obtained, then the landowner may be eligible for 1% to 2% reduction in their real property assessment. With the reduction in property assessment, the current landowner would benefit from reduced county property taxes each year. Thus, long-term beachfront homeowners would support the overall tax package (i.e. 2% transfer fee on the sale of the property coupled with the 1% to 2% reduction in real property assessment which is used to determine county taxes). This arrangement would have to be worked out between the State and the county.

To explain how the overall tax package would operate, a two million dollar beachfront home will be used as an example. If the home were to be sold for a price of two million dollars, the 2% transfer fee would generate a revenue of $40,000 that could go into a proposed State Beach Fund. The money could be used for erosion mitigation programs that benefit other beachfront homeowners and the public. Nevertheless, a significant number of beachfront homeowners may still object to the 2% transfer fee.

If the 2% transfer tax was coupled with a 1% to 2% reduction in property assessments at the county level, for lots that were in compliance with all shoreline regulations, then the beachfront homeowners would view the tax program more favorably. Using the two million dollar house as an example, the overall reduction in county property taxes can be calculated. Property tax rates for Oahu on March 3, 1992 were $3.25 per assessed value for the land, and $4.09 per assessed value for the improvements (Honolulu Advertiser, March 3, 1992). For the sake of discussion, it will be assumed that for the two million dollar house, one million dollars is the assessed land value and one million dollars is the assessed value of the improvements. A 1% reduction in the property assessment for the land would reduce the taxes owed to the county from $3,250.00 to $3,217.50. A 1% reduction in the property assessment for the land improvements would reduce county taxes from $4,090.00 to $4,049.10. The total county property taxes for the 2 million dollar beachfront home would be reduced from $7,340.00 to $7,266.60, or a total of $73.40 ever year. A 2% reduction in the property assessment would reduce the total property taxes by $146.80 per year. The exact percentage of property assessment reduction given by the county could be worked out later.

The effect on county treasuries from the property tax reduction can also be approximated. First, however, some estimates on the number of beachfront lots and illegal structures on the island must be obtained. According to one study, along 59 miles of surveyed beach, approximately 58%, or 34 miles were developed with residential uses (Sea Engineering & Moon, 1991). Along a stretch of approximately 11 miles of different beaches on Oahu, there are roughly 60 lots per mile of shoreline. About 27% of these lots are spanned by seawalls or revetments. Of the residential seawalls and revetments on Oahu, approximately 41% are illegal (Sea Engineering & Moon, 1991).

When the total number of miles of beaches with residential development is multiplied by the average number of lots per mile, an estimate of 2,040 total lots are obtained that span the beaches of the island [(34 miles) times (60 lots/mile)]. From the estimates in the paragraph above, there are approximately 226 illegal seawalls or revetments on the island [(2040 lots) times (27% lots with seawalls) times (41% illegal seawalls)]. This estimated number of illegal structures is in agreement with the approximations of the Department of Land Utilization. For this exercise, the total number of lots eligible for the reduced property assessment is about 1,814 properties (2020 properties - 226 with illegal structures).

The property assessment reduction, may cost the county $133,148 to $266,295 per year in property taxes ($73.40 to $146.80 per lot per year times 1,814 eligible lots). This is out of a total revenue from property assessments of $423 million per year (Honolulu Advertiser, March 3, 1992). To compensate the counties for reduced property tax revenues, the State could pay a higher fraction of the cost of improvements within a Beach Management District. The counties would be a major beneficiary of such improvements since healthy beaches provide recreational opportunities for county residents. In addition, any loss in county property taxes from the 1% to 2% reduction in property tax assessment maybe offset by an increase in revenue if a Beach Management District increases the value of beachfront homes.

A 1% to 2% reduction in property assessments might save the beachfront homeowner, who is in compliance with shoreline regulations, $73.40 to $146.80 per year. This property tax reduction, along with other beachfront management programs that offer financial and property protection, provide significant incentive for long-term homeowners to support the overall tax package.

The overall contributions to State revenues from the tax program could be significant. Assuming that of the 2,040 beachfront properties on Oahu, a property is sold on the average of once every 60 years. Using this assumption, there would be almost 34 sales of beachfront property each year. With an assumed average price of 2 million dollars, and a transfer fee of 2%, these sales would generate an annual revenue of 1.36 million dollars into the State Beach Fund.

Thus, more money will be raised by the State from the transfer tax ($1.36 million dollars/year) than the County will lose by the reduction in property taxes ($133,148 to $266,295 per year). It is important for the State to administer this money, since it will be a State agency that promotes beach district formation and evaluates the viability of various projects. In addition, it is the State that would pursue Federal assistance for various erosion control projects to reduce the costs for each party.

It should be reemphasized that the discussion of tax measures to further beach management programs is offered here not as a recommendation but as an option that the State should investigate. Many questions remain. For example, should the shoreline tax be imposed not only on beachfront property transfers, but also upon the issuance of a building permit? What are the constitutional issues related to taxing a group of homeowners along the coastline? What are the unique political and socioeconomic conditions in Hawaii that would impede the imposition of a transfer tax program similar to those in place in Massachusetts or Florida?

Any attempts to implement economic incentives and disincentives by taxation would require additional study (see Implementation Guidelines - Chapter XII). The discussion in this report is offered to show the reader that innovative tax strategies, if structured properly, can have a relatively minor impact on all parties, and can provide significant revenue for programs that benefit private landowners, the public, the counties and the State.

6. Impact Fees, Easements, and Other Funding Sources. There are many other sources of revenue for beach management programs that have not been discussed in this report. These include the sale of easements for private structures that encroach on State land, beach user fees, impact fees and tax deductible contributions from the public. All of these ideas could be further investigated by a proposed Division of State Beaches. Preliminary studies on these sources indicate that the potential income is relatively minor compared to those sources previously discussed in this chapter.

**B. Funding a BMD - Cost Allocation**

For Hawaii a shared cost system is proposed with contributions from the State, county and landowner. One starting point in the allocation of costs may be a scheme similar to that in Connecticut, where erosion control projects for private properties are split equally between the State, the local government and landowners. An allocation of costs where each party pays an equal share is easily understood and apparently fair. However, it may be possible to structure the allocation so that it is more politically feasible.

It is not the purpose of this study to recommend specific percentages. The exact percentages need to be worked out later between the State and the counties. The following should be considered in the allocation of cost for a BMD:

1. Federal - One duty of a proposed Division of State Beaches would be to actively pursue Federal funding for erosion control projects under the River and Harbor Act of 1962, Title I of Public Law 87-874, 76 Stat. 1173 (33 U.S.C.A. SS 426e-426g). If Federal funding is obtained, there is usually the requirement that local funds cover half the cost of the project with the Federal government to paying the remainder. For the following discussion, the term TOTAL COST means the

cost to design, engineer, implement and construct an erosion control project minus any contributions from the Federal government.

2. County - The individual counties should be required to pay a small amount for the improvements in a Beach Management District. A small payment by the county should be made since the counties benefit from a beach improvement project. In addition, the assessment provides economic incentive for the county to adopt land-use policies that preserve State beaches.

County cooperation in many of the programs discussed in this report is important. Therefore, the financial burden placed on the county should be minimized. It is suggested that individual counties be made to pay no more than 20% of the TOTAL COST of a Beach Management Program. A smaller fractional cost may be required to encourage county cooperation in certain programs.[4]

For example, the property transfer tax may be controversial. Yet this tax could provide the State with a continuous and significant source of revenue (See example - previous section). To make the transfer tax palatable, the tax could be linked with a county program to give a yearly 1% to 2% reduction in beachfront property assessments for properties that are in compliance with all coastal regulations. The overall tax package could be very attractive to the long-term beachfront owner.

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[4] There may be mechanisms for the State to require the counties to participate in the payment of capital improvements in a Beach Management District. In Maryland, once there is an approved financing plan, if the county or local government fail to pay the State its percentage of the cost, then the State Comptroller may withhold from State-collected, locally shared taxes; or from certain State grant programs; or from the State aid for police protection, a sum sufficient to reimburse the State for any amount that remains unpaid by the counties (Md. Nat. Res. Code Ann. S 8-1103). In Hawaii, a mechanism that requires the participation of the counties would need further investigation. While required participation may be valid for improvements within a BMD, required participation in other programs may be another matter. For example, the 1-2% reduction in property assessments discussed in this report is within the discretion of the counties. The Constitution of the State of Hawaii originally reserved to the State the duties of real property taxation, however, this has been amended so that the power is exercised exclusively by the counties (HRS-S 246A-1).

The counties may object if beachfront homeowners received a reduced property assessment for compliance with shoreline regulations since this would reduce tax revenues. As compensation to the counties, the State could agree to pay a higher portion of the costs for the capital improvements within a Beach Management District. For example, an allocation scheme may require that the counties pay only 10% of the cost of the improvements versus 20%. In return, the county would agree to provide a 1% to 2% reduction in property tax assessments to beachfront property owners, if they are in compliance with all regulations.

County funding may be provided by a capital projects fund, the general fund, or the issuance of general obligation bonds or improvement district bonds. Many States that have established BMDs have provisions that allow bonds to be issued to raise funds for the State or local share of the district.

3. Coastal Landowner - Coastal landowners receive specific benefits from a beach improvement project. One benefit would be an increase in property values, derived from the presence of a healthy beach that provides recreational opportunities and improved aesthetics, as compared to a shoreline with no beach that has been stabilized by a seawall. The major specific benefit would be the increased protection against wave energy that is given to their property by the improvement. This benefit should not be discounted. If sea-level continues to rise at the present rate, or the rise accelerates as most researchers predict, then the need for additional coastal protection to protect private property from greater levels of erosion would grow.

Since beachfront landowners receive specific benefits from the improvement district, they should be assessed a fair amount. Nevertheless, they should not be assessed so much that there is no economic incentive to join the BMD. If the majority of the landowners cannot cooperate, then a District may not be formed, and no one would benefit.

It is suggested that the landowner assessment be structured so that the fractional cost of paying for a project of surgebreakers[5] or sand replenishment be

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[5] Surgebreakers have been used to halt erosion at Kualoa Beach Park. One advantage of surgebreakers is the low cost compared to a detached breakwater. Such structures may transfer the erosion problem by interfering with longshore sand transport. Surgebreakers for residential use would require additional study.

less than paying the full costs of a revetment. Thus, economic incentive is created for the landowner to select options that preserve the beach and protect private property.

The exact percentage of the landowner's assessment could be worked out by a proposed Division of Beaches. An initial suggestion is that the landowner assessment range between 30%-45% of the TOTAL COST of the project. The exact amount would depend on several factors, including the type of improvement project, the total costs, and the degree of public benefit. If the pubic benefit from the project is great, then the landowner may be required to pay a smaller assessment (e.g., 30% in the discussed allocation scheme). If the public benefit is small, then the landowners would pay a larger fraction of the TOTAL COST and the State's contribution would be reduced.

4. State - Whatever costs of a BMD are not paid by the Federal government, the landowner, or the counties would need to be paid by the State. Assuming that the counties were to pay 10% of the TOTAL COST of the project, then the contribution from the State may range between 45%-60%. The contributions would be paid from a State Beach Fund. Revenues into the Fund would be derived from legislative appropriations, the issuance of bonds, federal contributions where applicable, and a tax on beachfront property transfers.

### C. State Beach Fund

Many coastal states have established dedicated State funds to support beach preservation activities. For example, Delaware has established a Beach Preservation Fund that is to have a minimum balance of one million dollars at the start of each fiscal year (Del. Code Ann. tit. 7, S 6808). The Fund is to be used to finance activities that enhance and preserve public and private beaches and mitigate beach erosion.

Two separate beach funds are established in Florida. The Beach Management Trust Fund receives monies from State appropriations and from permitting fees (Fla. Stat. Ann. S 161.0535, S 161.091). Disbursements from the Fund may be made by the Division of Beaches and Shores to carry out the State's responsibilities according to a comprehensive, long-range, management plan. The plan deals with erosion control, beach preservation, beach restoration, beach renourishment, dune construction and coastal studies. In addition, Florida has established an Erosion Control Trust Fund with revenues to the Fund derived from fines and awards of damages for regulatory violations (Fla. Stat. Ann. S 161.054).

In Maine, the State owns less than 3% of the coastline, which is the lowest percentage of publicly owned shoreline in any coastal State in the United States. To deal with the problem of limited public access, the State has established a Shoreline Public Access Protection Fund to support the acquisition and development of shoreland areas for public use.

In Louisiana, there is the Coastal Resources Trust Fund where capital is derived from State appropriation and surplus funds from other accounts. The money is used for the State's coastal resource programs (La. Rev. Stat. Ann. S 49:213.22, 49:214.40).

For Maryland, an Ocean Beach Replenishment Fund is established with monies from State appropriations, bonds, and local contributions ((Md. Nat. Res. Code Ann. S 8-1003). The Fund is maintained for bulkhead construction, dune restoration, beach replenishment, and land acquisition. Monies from the Fund may not revert to the General Fund of the State. For land acquisition, the State pays 100% of the cost from the Fund. For all other activities the State contribution is limited to 50% of the total cost.

Federal programs that provide financial assistance for beach erosion control projects require that the costs be shared with either the State, municipality, or other political subdivision in which the project is located (33 U.S.C.A. 426e). North Carolina has established the Beach Erosion Control Project Revolving Fund that consists of monies from State appropriations and other sources. The Fund is used to finance the local portion of the nonfederal share of the cost of beach erosion control projects (N. C. St. S 143-215.62).

Similarly, Virginia has established a State fund to help local governments pay for half of the nonfederal costs of erosion abatement projects. Unexpended monies go into the Special Emergency Assistance Fund, which is used, in part, to restore beaches destroyed by storms or hurricanes.

From the above examples, dedicated State beach funds have been used to buy coastal land, develop access routes, support coastal research, education and management programs, finance erosion control capital improvements, and provide emergency assistance. For Hawaii, it is suggested that a dedicated fund be established to further beach preservation activities. A Hawaii State Beach Fund should be established to capitalize BMD projects, acquire selected coastal properties, pay for renourishment projects, and fund coastal and engineering studies benefitting the State and landowners. Money for the Fund would be derived from State appropriations, Federal contributions where applicable, local contributions, and the shoreline property transfer tax.[6]

The need for a dedicated beach fund is clear. Certain erosion control measures may fail without proper maintenance. For example, the long-term effectiveness of a sand replenishment project may deteriorate without periodic sand renourishment. Without a dedicated source of funding, any financial contributions the State would make with regard to scheduled maintenance could be postponed because of other priorities. This could leave coastal landowners without adequate protection of their properties.

Another reason for a dedicated fund is that many beaches will need to be monitored on a periodic basis. Monitoring is required for two purposes. First, the stability of a beach fill should be checked to improve our poor understanding and prediction capability of erosion processes, and help track erosion on a statewide level. Second, monitoring is needed to search for dangerous unnatural conditions that may expose the State to liability for failed erosion control structures. Monitoring activities must be continuous and cannot be subject to the whims of the political process.

Finally, a dedicated State Beach Fund allows financial reserves to be built up for the inevitable storm or hurricane that will hit the islands. After a storm event, opportunities may exist to provide financial assistance to the landowners and recover the eroded beach. A dedicated Beach Fund would facilitate the accumulation of the necessary financial reserves.

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[6] For landowner assessments within an improvement district, a separate fund may be needed so that monies are not commingled. There is the legal requirement that assessments for improvements must stay within the district.

## VIII. REGULATORY OPTIONS

Since the formation of an beach improvement district may not be feasible for every shoreline in the State, other beachfront management options are discussed that may lead to increased beach preservation. The three options include the development of a voluntary relocation program, modifications of the State shoreline setback and strategies for improved enforcement of existing shoreline regulations. As with all options developed in this report, considerable attention is given to the concerns of the private property owner.

### A. National Flood Insurance - Upton-Jones Amendment

Before 1988, the National Flood Insurance Program paid insurance benefits only to those insured buildings that had sustained physical damage as a result of flooding or flood-related erosion. Beginning in 1988, the Upton-Jones Amendment to the National Flood Insurance Program authorized advance payments of insurance benefits if a landowner's home is threatened by erosion and the landowner demolishes or relocates the structure (Section 544, Housing and Community Development Act of 1987). Under Upton-Jones, payments for demolition before collapse are 110 percent of the value of the structure. Of this payment, 10 percent is to cover the cost of demolition. If a structure is relocated instead of demolished, payment would be the actual cost of relocation, up to 40 percent of the value of the structure.

Value of the structure, as determined by the amendment, is the lower of 1) the value of a comparable structure that is not subject to imminent collapse; 2) the price paid for the structure and any improvements to the structure; or 3) the value of the structure under the insurance contract.

To qualify for erosion benefits, the homeowner must be covered by Federal Flood Insurance on or before June 1,1988. In addition, the homeowner must have the insurance at least two years before certification that the structure is in a zone of imminent collapse. The statutory period may be reduced if home ownership is less than two years.

In determining the zone of imminent collapse, the Federal Emergency Management Agency has adopted interim criteria. Presently, the zone is defined as the area seaward of a line that is 10 feet plus five times the local average annual erosion recession rate as measured by the vegetation line, a dune line or the high tide line. For structures that fall outside this zone, FEMA will consider any technical or scientific data that demonstrates a unique or highly unstable condition at the site (National Research Council, 1990). Erosion benefits may be available even for those properties that have been stabilized by seawalls (Michael Buckley, pers. comm., Federal Emergency Management Agency). For stabilized shorelines, such factors as the design of the structure, the amount of maintenance, local geomorphic features, and historical and spatial changes in the beach system may be considered to determine a zone of imminent collapse.

Under Upton-Jones, individual States and local governments may certify that a structure is in a zone of imminent collapse if they adopt a statewide coastal zone setback program that is based, in part, on a multiple of the local shoreline recession rate. Several States, such as North Carolina, Michigan, South Carolina, and Pennsylvania, have already qualified to make certifications (National Research Council, 1990). Other coastal States are developing their program. For example, in Texas, it is the General Land Office that acts as the lead agency for the coordination of coastal erosion avoidance and planning (Tex. Nat. Res. Code S 33.601). The Commissioner of the General Land Office is authorized to perform all acts necessary to develop and implement a program of certification of structures subject to imminent collapse due to erosion.

If a beachfront home is constantly threatened by erosion, or in a zone of imminent collapse, the landowner may welcome the option of receiving advanced insurance payments to relocate or demolish the structure. The economic incentive to landowners could be made even greater if Upton-Jones insurance payments to demolish the building were combined with a State program to purchase the underlying land. For minimum economic loss, landowners would benefit if they avoid a situation where waves are regularly threatening private property. The public would also benefit. In many instances, it may be possible to recover lost beaches simply by moving erosion control structures inland.

A proposed Division of Beaches could work to develop and implement a State certification program where landowners benefit from erosion payments under the Upton-Jones Amendment. In addition, the Division could develop a program where payments from the State Beach Fund are used to provide additional economic incentive to move off selected beach areas.

## B. Zoning

Once development occurs near an unstable shoreline, protection of the structures and preservation of the beach become considerably more costly and complex. This is exemplified by the numerous suggestions in this report to establish and fund a Beach Management District System for the State. In addition, halting a receding shoreline with protective structures may benefit only a few and seriously degrade the natural beach and the value it holds for the majority. Therefore, it is recommended that land use policies along the coastline be reevaluated to address the continued loss of beaches and the future problems associated with sea-level rise.

It is vital that shoreline instability be anticipated at the earliest stages of zoning. In many areas, proper planning may be the only way to achieve the dual objective of beach preservation and protection of property rights. This study proposes a new setback line for large tracts of undeveloped land. The shoreline setback would apply to new developments that require the subdivision of land or are located in a non-urban district. These new setbacks need not apply to rocky shorelines since these coastal sectors are considerably more stable than the beach areas. Nevertheless, it maybe decided to apply the new setback to all shorelines to protect scenic or open space resources, or to simplify administration of the setback law.

It is proposed that the shoreline setback for sand beaches be the greater of:

1) 60 feet from the natural vegetation line; or

2) 30 times the annual average erosion rate of the natural vegetation line; or

3) the historic range in the position of the unstabilized vegetation line over a minimum of 30 years.

Reduction of the setback should be granted if it is necessary to maintain buildable area. If a new setback reduces the buildable area by 50% or more, an exception could be made to allow a smaller setback. This exception is analogous to the setback provisions for small lots at the county level. On Oahu, Kauai and Hawaii, if a 40 foot setback reduces the buildable area by 50%, a 20 foot setback is allowed. The 50% provision could also apply to new subdivisions and newly reclassified urban land.

There are many ways to structure the setback reduction. Either, the setback could be halved, as for small lots on Oahu, Kauai, and Hawaii. Alternatively, the setback could be reduced until a 50% buildable area is achieved. The later alternative would provide more protection to the beach resources of the State. The exact reduction strategy would need further investigation.

For each parcel of land, the setback reduction may apply only one time. This prevents the practice of numerous subdivisions to obtain multiple reductions with smaller and smaller setbacks.

The setback as proposed has the following features:

1) In the future, the eligibility of the State to obtain Federal assistance for erosion control projects may be dependent on the State adopting a setback with a 30-year annual average erosion rate. Presently, the State is eligible for Federal funding and assistance from the Secretary of the Army for small shore and beach restoration and protection projects (33 USCA S 426g). Federal funds of up to $2,000,000 can be allotted for shore erosion mitigation projects that benefit both the public and the private landowners, provided the State or local government share in the cost of the project. This funding could help offset the State and county cost of improvements within a Beach Management District. Congress is to consider the elimination of Federal assistance unless the State adopts a beach front management program that includes restrictions on new development seaward of a setback based on a 30-year annual average erosion rate (33 USCA S 426e).

2) The use of an annual average erosion rate allows the State to certify for approval those homes that may benefit under the Upton-Jones amendment to the National Flood Insurance Act of 1968 (44 CFR Part 63). Money from the Upton-Jones program for relocation or demolition, can be coupled with funding from the State to develop a voluntary program to move structures inland. This program should be viewed favorably by coastal landowners since it provides additional financial protection against coastal erosion, sea-level rise, and storm events. In addition, the removal or relocation of certain erosion control structures inland may allow the recovery of a lost beach.

3) The 30-year erosion setback proposed in this study is consistent with provisions in the Upton-Jones amendment. Specifically, the amendment states that future flood insurance coverage and certain types of federal disaster assistance will be available only for buildings that are constructed or relocated inland of a 30-year construction setback (Public Law 100-242-Feb.5, 1988). While the Upton-Jones amendment applies to relocation benefits for pre-existing structures, the setback rule discussed in this report would apply to new structures. It is inconsistent to have a 30-year erosion setback for the relocation of existing structures and the 20-40 foot setback now in effect in Hawaii for new structures (HRS-205A-41).

4) The setback reduction to preserve buildable area prevents the situation where high erosion rates or extremely unstable shorelines result in the elimination of the use of the land. By preserving buildable area and maintaining "economically viable use of the land," the success of a takings challenge, even after the Lucas case (Chapter III), is greatly diminished. While the takings issue may still be raised by landowners, the merit of their claim is significantly reduced. It is one strategy of this report to address the concerns of the public and the private landowner. Therefore zoning strategies are formulated to stay clear of the regulatory takings problem. This is especially critical given the recent decision by the U.S. Supreme Court in Lucas.

5) Besides the preservation of buildable area, additional constitutional protection is provided by the proposed setback. As discussed in Chapter III, a regulation may be held invalid if it "does not substantially advance legitimate state interest" or "denies an owner economically viable use" of the land (Agins v. Tiburon, 447 U. S. 255, 100 S. Ct. 2138, 65 L. Ed. 2d 106 (1980). In determining if the regulation "substantially advances legitimate state interest," the courts will consider, among other factors, (a) if there is a legitimate state interest and (b) if the regulation is overly broad or more restrictive than necessary to achieve the state interest.

The legitimate state interest of the setback proposed in this study is the protection of public access and the prevention of serious harm to public trust lands (see, Figs. 2 through 5). In addition, the proposed setback is no more restrictive than needed to advance these legitimate government interests. For example, if the shoreline is stable or accreting, the setback would be, at the most, 60 feet. Contrast the 60-foot setback with the proposal in House Bill 893 (1991 legislative session) which required a 150-foot setback for all non-urban land according to the State land use classification scheme. Landowners could claim the 150 foot setback as being overly broad, if their shoreline was relatively stable or subject to accretion. However, the State could counter that the 150 foot setback has objectives other than beach preservation, such as the protection of scenic and open space resources.

6) For relatively stable or accreting shorelines, the setback of 60 feet is not unduly burdensome. Landowners would appreciate the 60-foot setback over the 150-foot setback proposed for non-urban land in House Bill 893 (1991 legislative session). The City and County of Honolulu has recently adopted a 60-foot setback for all new subdivisions. The need to extend the setback a minimum of 60 feet from the old distance of 40 feet is exemplified by the numerous beaches that have been lost even though they are relatively stable (e.g., Kahala - Fig. 3). The increased setback of 60 foot setback would further advance the CZM objectives of scenic and open space resource preservation and coastal ecosystem protection.

7) The proposed setback will help protect the beach resource. For the few beach sectors that are chronically eroding (similar to Iroquois Point - Fig. 2) or highly unstable (similar to the southeast end of Lanikai Beach - Fig. 5) the proposed setback would offer more protection than the 60-foot or, if needed, the 150-foot setback. By allowing the beach to migrate naturally, the need for hardening of the shoreline can be reduced or eliminated, and the pubic trust resource can be preserved for future generations (Fig. 22).

In those instances where the shoreline setback is greater than 60 feet, a program should be instigated where the landowner can be given variances for increased height, greater density, or a reduced front and side setback for land adjacent to the beach. By the use of compensating variances, it may be possible to maintain a significant amount of buildable area even with a greater shoreline setback. Under ideal conditions, the landowner could have the best of both worlds (i.e., the same amount of buildable area as before the expanded shoreline setback and a healthy beach/dune buffer system that protects the property from wave attack). If packages of variances were offered to those landowners who would have setbacks greater than 60 feet, the use of an overlay district to define areas subject to different land use controls may be ideal (Robin Foster, pers. comm., Lacayo Planning Inc.). Alternatively, a new zoning designation at the State or County level could define appropriate construction and land use guidelines so that buildable area is maintained while the beach is preserved.

Economic burden on the landowner can also be alleviated by developing a program of Transferable Development Rights (TDR's). The theory behind TDR's is that they allow the owner of the right to build more of something on a designated parcel of land than the normal development regulations would allow. TDR's can be used by the beachfront landowner on other inland property they may own. If no other property is owned, the impacted landowner may sell the right to another inland landowner. Thus, TDR's can be used as a form of compensation for those landowners that are impacted by an increased shoreline setback. Setting up a system that transfers development rights from the restricted area (sending area) to land on which the TDR can be used (receiving area) can be extremely complex (Hagman & Juergensmeyer, 1986). The use of a system of TDR's would require additional study.

To further reduce the economic burden on the landowner, the shoreline setback may be reduced if a beach replenishment project designed to preserve the beach has been funded and permitted before development begins on the site. Other States have provisions in their setback laws that allow for reduced setbacks for established replenishment projects (Fla. Stat. Ann. S 161.053 (6)(d); S. C. Code Ann. S 48-39-280). The landowner would be able to work with the proposed Division of State Beaches to receive technical assistance on the types of sand replenishment projects that may be useful in reducing the proposed setback. In addition, the proposed Division of State Beaches could investigate the possibility of providing a fraction of the cost of the erosion control project, if the landowners project would benefit the public.

In sum, the State and county should make the greatest effort to coordinate land use policy so that beaches can be preserved while the landowner is compensated. Most promising appears to be a program of compensating variances, Transferable Development Rights and reduced setbacks for preapproved and prefinanced sand replenishment projects.

Increasing the shoreline setback raises the issue of what effect this increase will have on existing legal residences. The concern of a coastal homeowner could be that if a home becomes nonconforming and restrictions are placed on the reconstruction of a house should it be destroyed, then the homeowner may not be able to finance, refinance or insure the house. To protect the homeowner, it is suggested that there be provisions in the proposed setback ordinance that allow reconstruction of a home, in the case of damage, as long as the new residence is not enlarged or placed further seaward. If a building is destroyed by an act of God, it may be held that a nonconforming structure can be rebuilt. (Hagman & Juergensmeyer, 1986).

The wisdom of allowing a home destroyed by storm waves or erosion to be rebuilt may be questioned. Nevertheless, this report attempts to address the concerns of the private property owner. Rather than moving existing landowners inland by prohibiting the repair of nonconforming homes, a strategy of coastal retreat could be provided through a voluntary program that offers economic incentives for coastal landowners (section A of this Chapter). Another economic incentive, as it pertains to damaged nonconforming houses, is to grant an allowance or credit to reconstruct a larger house, if the most seaward portion of the new house is moved inland. A formula that relates the allowed size increase of the house with the distance moved inland could be worked up by the appropriate county authorities.

Regarding the implementation of the proposed shoreline setback ordinance, it would be the applicant or landowner who would fund a coastal study to determine the appropriate setback. Previous aerial photographic and historical studies would be allowed as a substitute for the coastal study, where suitable data and analysis exist for the beach segment in question. Placing the burden on the coastal landowner to conduct the erosion study would relieve the State of the financial burden of analyzing all the State's shorelines. To ensure technical accuracy, the State could have in house staff with technical backgrounds to review the scope, methods and accuracy of the erosion studies. It should be noted that many environmental regulations require the applicant of the activity, not the government agency, to conduct appropriate scientific studies (e.g., EIS under the National Environmental Policy Act, or monitoring for a storm water permit under the Clean Water Act).

In the Kauai County Zoning Ordinance (SEC. 8-13.1), there is a designation of Shore Districts. One requirement is that the applicant for a permit to build within the Shore District must provide an information report. The report describes the rate of Shore District Change over time under both natural and proposed artificial conditions. The Shore District designation in Kauai is a type of overlay district (see Chapter V). The requirement of an information report in Kauai's Zoning Ordinance is analogous to the proposal in this report that all new beachfront subdivisions or developments on nonurban land conduct a coastal erosion study that determines the shoreline setback according to the proposed setback rule.

It could be a proposed Division of Beaches that would adopt the rules, procedures and technical requirements on how the average annual erosion rate and the historical range in the position of the vegetation line are determined for each beach sector. The Division can monitor data on sea-level rise, and if appropriate, factor the local data into the calculations. Where the shoreline has been altered artificially, the Division could develop guidelines for the establishment of a setback using other criteria, such as the historical changes on adjacent property, or on the mean high water line. All rules that the Division adopts should insure proper legal procedures, fairness and objectivity.

**C. Enforcement**

Many of the problems along the coast are due to lack of enforcement of existing laws. Significant improvement in the management of beaches could be made if existing laws were enforced. During Coastal Zone Management public workshops in 1990, it was noted that there were significant instances of non-compliance and illegal, non-permitted uses and developments. In one CZM study, it was noted that along a stretch of Lanikai Beach consisting of 36 lots, there were 22 illegal seawalls and 9 non-conforming walls. Only two of the seawalls had the appropriate permits (Edward K. Noda and Associates Inc., 1989). In another study of selected beach sites on Oahu, approximately 41% of the structures along the shoreline were illegal (Sea Engineering & Moon, 1991).

As with the enforcement of other environmental regulations in the State, there is a constant shortage of staff and funding to monitor and enforce coastal regulations. As a result, many illegal activities go unnoticed. For those illegal activities that are discovered, there is the problem of no effort to follow through with enforcement action. Other coastal states have addressed this problem by establishing dedicated funds specifically for enforcement. For example, in Florida, the Erosion Control Trust Fund is established with monies from fines or awards of damage for regulatory violations (Fla. Stat. Ann. S 161.054).

It is suggested that Hawaii establish a dedicated Beach Enforcement Fund. An initial legislative appropriation could be made into the Fund. Money in the Fund would be used specifically for beach enforcement activities, including the hiring of personnel, monitoring of the shoreline, citation of violators, and court action if necessary. Any fines collected for violations of the setback law or the SMA, or any damage awards would go into the Beach Enforcement Fund for future enforcement activities. Thus, the fund may, but need not be, self perpetuating.

Nevertheless, there is more to the problem of enforcement than just a lack of money to hire enforcement personnel and county corporation counsel. With regard to illegal seawalls and revetments, enforcement action is hampered by opposing factors. For example, enforcement action should be uniform. While agencies are given discretion in the enforcement of rules, they cannot patently abuse that discretion. The need for consistent enforcement is difficult when some homeowners may be in dire need of the protection offered by illegal seawalls and revetments to protect their property. Stiff penalties to remove illegal structures could be viewed by government agencies as harsh or draconian. Variances for hardship could be granted, but to date few counties have any policy that defines true hardship. Therefore, there is a tendency to grant a hardship variance whenever property is threatened by erosion. Another alternative is to use the Beach Enforcement Fund to develop a program of fines and subsidies.

The Beach Enforcement Fund could provide a new way in which enforcement action is viewed and undertaken. For illegal seawalls and revetments, a carrot and stick approach could be developed. The stick would be in the form of fines, to encourage landowners to obtain the proper permits or remove the illegal structures. For the case where houses are so close to the shoreline that removal of a seawall would expose the residence to wave action, then low-level fines, rather than hardship variances should be considered. The amount of the low-level fine would be at the discretion of the administering agency, but some degree of uniformity in setting the fines should be achieved. For example, if the house is less than 10 feet from the seawall, a fine of $1,000 to $2,000 dollars per year could be imposed, rather than granting a hardship variance. Revenues from low-level fines can be placed in the Beach Enforcement Fund. Money from the Fund can then be used to provide subsidies to help landowners convert illegal and legal vertical seawalls to buried erosion control structures. <u>For many areas, the movement of vertical walls and other steep structures away from the tidal zone could lead to the temporary recovery of a lost beach.</u>

Thus, the Beach Enforcement Fund provides a needed degree of flexibility. For unavoidable actions that affect the beach, low-level fines can provide financial support for programs that restore or preserve beaches at other locations. For flagrant violations of the shoreline setback or SMA law, the fines can be increased to provide ample deterrence, financial support for enforcement activities and subsidies for the seawall conversion program. In setting fines, factors that may be considered include, but are not limited to: i) the distance of the residence from the shoreline; ii) the need for the structure after considering historical erosion patterns and oceanographic wave characteristics; iii) the potential impact of the illegal activity on the adjacent shoreline; and iv) past dealings with the administrative agency.

The Beach Enforcement Fund should be viewed favorably by a majority of beachfront homeowners on the island. Approximately 90% of the beachfront homeowners are in compliance with the law (See Chapter 7 on taxes; an estimated 27% of the beachfront lots on Oahu have seawalls or revetments; about 41% are illegal). As long as a homeowner is in compliance with the law, there would be no threat of fines. In addition, the homeowner may be eligible for subsidies to build buried erosion control structures, should their property be threatened by erosion.

Beach enforcement funds could be established at the State or county level, depending on the government agency that takes the lead in beach enforcement activities. The advantage of enforcement at the county level is that the counties are currently conducting enforcement activities for illegal structures. Therefore, State enforcement proceedings may detract or duplicate county activities. The disadvantage of county enforcement is that individual county concerns may be given precedence over preservation of the State's beaches. One workable solution would be to have the counties continue their enforcement work with some monitoring by a State agency. The Office of State Planning, as lead agency for the Coastal Zone Management Program, has the duty to monitor the activities of State and county agencies to ensure that they adhere to the CZM objective and policies. It is suggested that a new objective and policy be added to HRS-205A-2 that specifically addresses the problem of beach loss and the preservation of sandy shorelines.

## IX. DIVISION OF STATE BEACHES

Numerous coastal states have established offices of beaches whose function is to administer beach management programs. For instance, in Delaware, the authority to enhance, preserve and protect public and private beaches is vested solely in the State Department of Natural Resources and Environmental Control. The Department can construct and maintain groins, jetties, bulkheads, dunes, breakwaters and other facilities along any public beach or shoreline area in the State (7 Del. C. S 6803). In Florida, there is the Division of Beaches and Shores within the Department of Natural Resources that develops, maintains and administers the comprehensive long-term Beach Management Plan for the State (Fla. Stat. Ann. S 161.161). In Rhode Island, it is the Department of Environmental Management that has the authority to devise and implement economical and effective methods for preventing beach erosion (R. I. Gen. Laws S 46-3-4).

Coastal studies in Hawaii have recommended the formation of an "Office of Beaches" (see, e.g., Oceanit, 1990). In 1991, House Bill 219 was to establish an Office of Beaches within the Department of Land and Natural Resources. Its purpose was to advocate protection, improvement, and creation of beaches, manage beach resources, and initiate public beach widening and regional beach stabilization projects. The Office would have facilitated the formation of beach districts and the use of sand replenishment. The Bill passed through the Water, Land Use and Hawaiian Affairs Committee, and through two readings in the House. However, the Bill died in the House Finance Committee.

As discussed in Chapter V, the formation of a Beach Management District requires active coordination and participation by a government agency. Efforts by other coastal States to form a Beach Management District without an active government role have been futile.

It is recommended that an agency be established within the State to administer a Beachfront Management Program, and actively promote, coordinate, and administer the formation of BMDs. The new agency could be set up as an Office, a Branch of a Division, or a Division of a Department. Alternatively, the Coastal Zone Management Program, or a unit within the Department of Land and Natural Resources could be expanded and given new duties. It is not the purpose of this report to recommend the exact structure of the entity. Further study would be required (see Implementation Guidelines - Chapter XII). For the sole purpose of discussion, it is assumed that a Division of Beaches is formed. The reader should be aware that although the entity is referred to as a Division of Beaches, this is not a recommendation on its structure, organization or association.

Assuming a Division of State Beaches is adopted, the new Division would be required to develop and administer many of the programs proposed in this report. The Division of Beaches would have numerous duties, including the following:

1) Pursue Federal Funding. There are two federal programs from which the Division should actively seek assistance. Under the Upton-Jones amendment of the National Flood Insurance Act, benefit payments from flood insurance coverage may be provided for certain homeowners threatened by erosion. If Hawaii were to qualify for such a program, the Division of Beaches could play an active role in helping landowners take advantage of this program. The Division could also pursue federal assistance under the River and Harbors Act to pay for small erosion control projects that benefit the public and private sectors (33 USCA S 426e-426g). Payments under this program could be used to help finance the capital improvements in a Beach Management District.

2) Voluntary Relocation Program. The Division could develop a voluntary relocation program whereby payments under the Upton-Jones amendment of the National Flood Insurance Act are combined with money from the State Beach Fund to provide homeowners an economic incentive to demolish or move their homes off erosion-prone beaches.

3) Government Coordination. The Division would coordinate activities with federal, State and county agencies to mitigate erosion and manage the shoreline. Cooperation would be critical in the areas of funding and establishing Beach Management Districts.

4) Shoreline Setback Regulation. If a shoreline setback rule was adopted as proposed in Chapter VIII, the new Division would need to develop rules regarding the technical requirements for determining the average annual erosion rate and the historical range in the position of the vegetation line. The rules should cover minimum technical standards as well as procedural matters that ensure proper due process to the applicant. The shoreline setback would apply to new development

on land that has not been subdivided or zoned for urban use. The Division could work with landowners to determine the appropriate setback, either through previous studies or with the help of the landowner's consultants.

5) Beach Fund Administration. The Division would establish guidelines for the collection, expenditure and accounting of monies in the State Beach Fund. The Division would also investigate the possibility of providing no-interest loans from the Fund to homeowners for shoreline preservation projects.

6) Legislative Funding. Specific requests for legislative appropriation may be necessary to maintain the State Beach Funds and to finance certain preservation projects. The Division would prepare such requests.

7) Permitting Assistance. The Division would work with the counties and landowners in permitting erosion-control options along the shore. For projects that require buried erosion control structures, the Division would ensure compliance with the National Historic Preservation Act and the State's historic preservation law (HRS - 6E). For projects that require activities on the beach or offshore, the Division would become the lead-agency in permitting. Where technical data is required that is not site specific, the Division could provide such information.

Where it is possible to consolidate and coordinate effort among permits, hearings, and applications for variances, the Division would strive to do so by interagency agreements. These agreements would be similar to those now in effect between the Department of Land and Natural Resources and the Department of Transportation. The Department of Land and Natural Resources has established a process to get all government agencies involved during the issuance of their conservation district permits (Roger Evans, pers. comm., DLNR). Nevertheless, up to six permits may still be required by Federal and State law. The Division of State Beaches could help the applicant by developing, for each specific erosion control measure, a master application form which contains sufficient information for all affected agencies. Copies of the completed application could then be sent to all affected agencies for further evaluation. Such a strategy could significantly reduce the permitting time and costs for landowners. Through these streamlining measures, a new government agency and more regulation may not necessarily mean more bureaucracy for the landowner. Nevertheless, the goal of one window permitting is probably unlikely, since some of the government agencies have their own specific requirements. For example, the Department of Health Water Quality

Certification Permit under Section 401 of the Clean Water Act may require monitoring of the water before, during or after a proposed activity. This requirement is unique to the DOH, and requires the applicant to coordinate the monitoring with the Department.

8) Technical Assistance. Technical assistance on beach replenishment and other erosion mitigation options needs to be provided to property owners and the counties. The Division would provide such assistance either by in-house staff, or with the use of a consultants.

9) Erosion Control Mitigation Design. The Division would actively explore all practical and economic methods to control shore erosion. The Division would design, or cause to be designed through outside help, specifications on erosion control structures for homeowners, which are suitable under a defined range of coastal parameters.

10) Disaster Plan. A disaster plan could be developed which would allow State acquisition of coastal properties from those who wish to sell after a major storm, tsunami, or hurricane. The plan would also develop post-storm emergency measures to assist the counties and coastal landowners. This plan would have to be coordinated with the emergency plans of the State Civil Defense Agency.

11) Rulemaking. The Division would establish rules and criteria to place priorities on:

a) those shorelines which can be effectively replenished with sand;

b) those shoreline sectors which would benefit from the formation of Beach Management Districts;

c) those shoreline sectors which should be acquired;

12) Scientific and Technological Research. The Division would help to coordinate and initiate research related to the following:

a) a statewide inventory of onshore and offshore sand resources, including economic and engineering feasibility studies of resource use.

b) a study of natural and human processes that have an impact on Hawaiian beaches, such as storm frequency and coastal development trends.

c) a long-term monitoring program of the State's shorelines in high-resolution, repetitive field surveys and historical shoreline analyses.

d) the tracking of research concerning global sea-level rise, and the continued analysis and monitoring of local sea-level rise.

13) Public Education. The Division would develop a program to educate the public on various aspects of shoreline erosion, coastal hazards and sea-level rise.

14) Sand Replenishment. The Division should investigate the feasibility of a State beach renourishment program that operates all year on all the islands. Such a program would reduce the cost per cubic yard to renourish beaches. This program has been suggested by other coastal studies (Oceanit, 1990).

15) Administration. The Division would develop, implement and administer a comprehensive long-range beach management plan for the State of Hawaii.

# X. CASE STUDIES

One goal of this study was to develop a menu of beach management options of which one or more of the alternatives could apply for every mile of the shoreline. In order to test the ideas in this report, Kahala Beach and Ewa Beach have been chosen for case studies. These sites represent a wide range of socioeconomic conditions. At Kahala, an attempt will be made to apply the improvement district concept to test the feasibility of a sand replenishment project. At Ewa Beach, the overlay district concept will be applied to test new programs that the county may wish to implement. In order to show how the programs discussed in this report would work, it is assumed that a Division of Beaches has been formed.

## A. Ewa Beach

1. Location. Ewa Beach is located to the west of the entrance to Pearl Harbor (Fig. 35). The area of interest is bounded by Ewa Beach Park on the east and the rocky coastline near Muumuu Place to the west. This rocky coastline marks the western end of the littoral cell (Fig. 36). The area of interest spans a length of approximately 1.5 miles. The beachfront lots discussed in this section are covered by tax map keys 9-1-28, 9-1-25; 9-1-7; 9-1-6; 9-1-24; 9-1-23 and 9-1-5.

2. Zoning. The area of interest is designated as Urban on the State Land Use Commission Maps (Fig. 37). On the Oahu Development Plan, the area has been zoned for residential use (Fig. 38). Specifically, the residential areas are zoned R-5 (Fig. 39). According to the Oahu Land-Use Ordinance, R-5 zoning has a minimum lot area of 5,000 sq. ft. and a minimum lot width of 50 feet. The area is also designated on the National Flood Insurance maps as AE and VE zones (Fig. 40). The west end of Ewa Beach is in the AE zone, which indicates the area is subject to coastal flooding. The east end of Ewa Beach is in the VE, zone which indicates that the area is subject to flooding and wave action.

3. Socioeconomic Setting. According to census figures, over the last 20 years, the Ewa region has experienced population growth at almost twice the rate of the rest of Oahu. In 1970, Ewa's population was 24,087 persons. During the 1980's, the population increased to 38,324 persons, which is an increase of 59 per cent. By 1990 the population had increased to 42,983 persons, or another 12 per cent. New development projects in the area are expected to significantly add to the

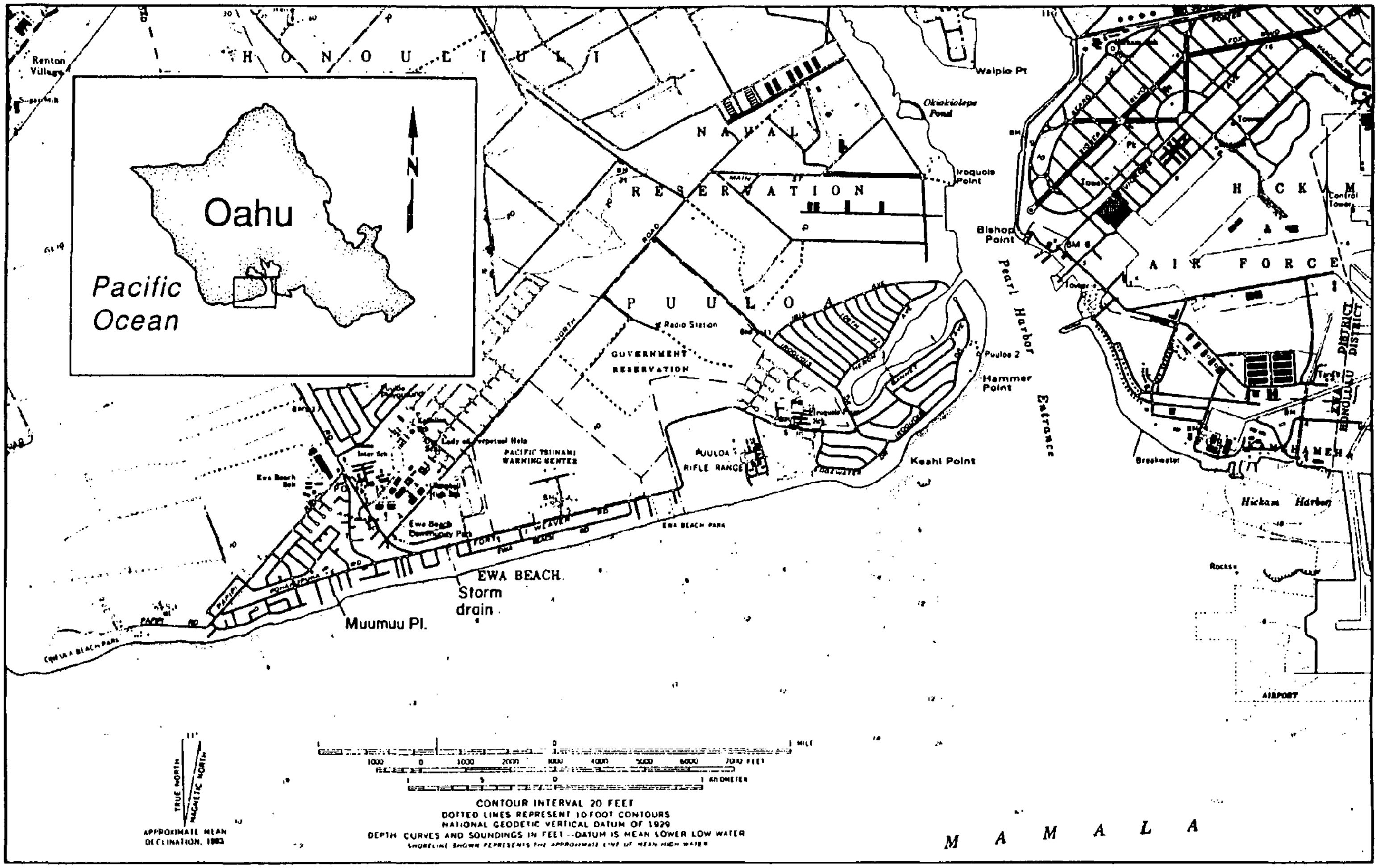


Figure 35. Ewa Beach Location.

Figure 36. Ewa Beach - Boundaries of Area of Interest. **TOP**: Looking east from the west end of Ewa Beach. The west end of the Ewa littoral cell is bounded by an emergent limestone reef. **BOTTOM**: Looking west from the east end of Ewa Beach. This photo was taken near Ewa Beach Park. In general, the beach is wide and the houses are well set back.

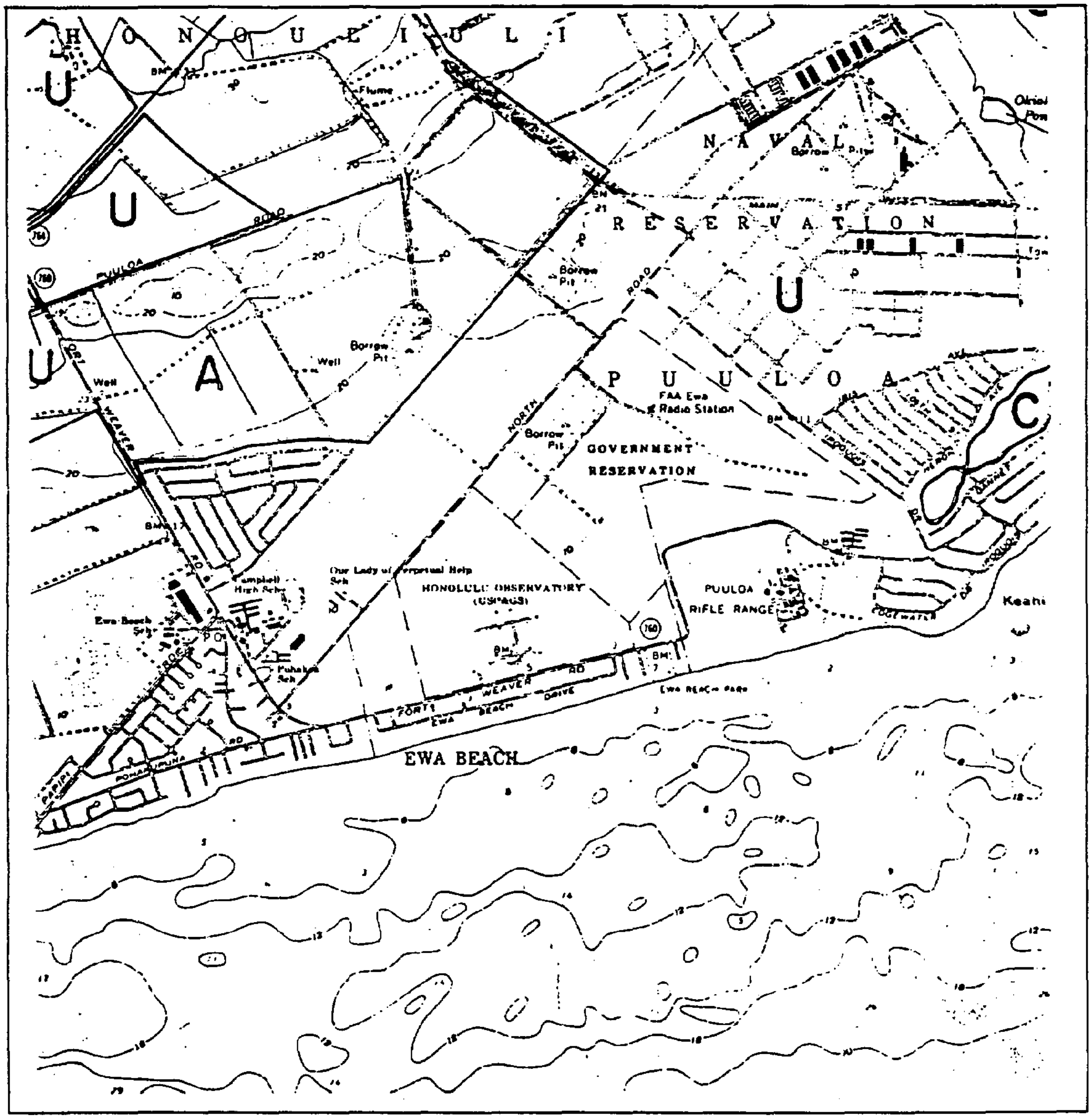


Figure 37. Hawaii Land Use District Map for Ewa.

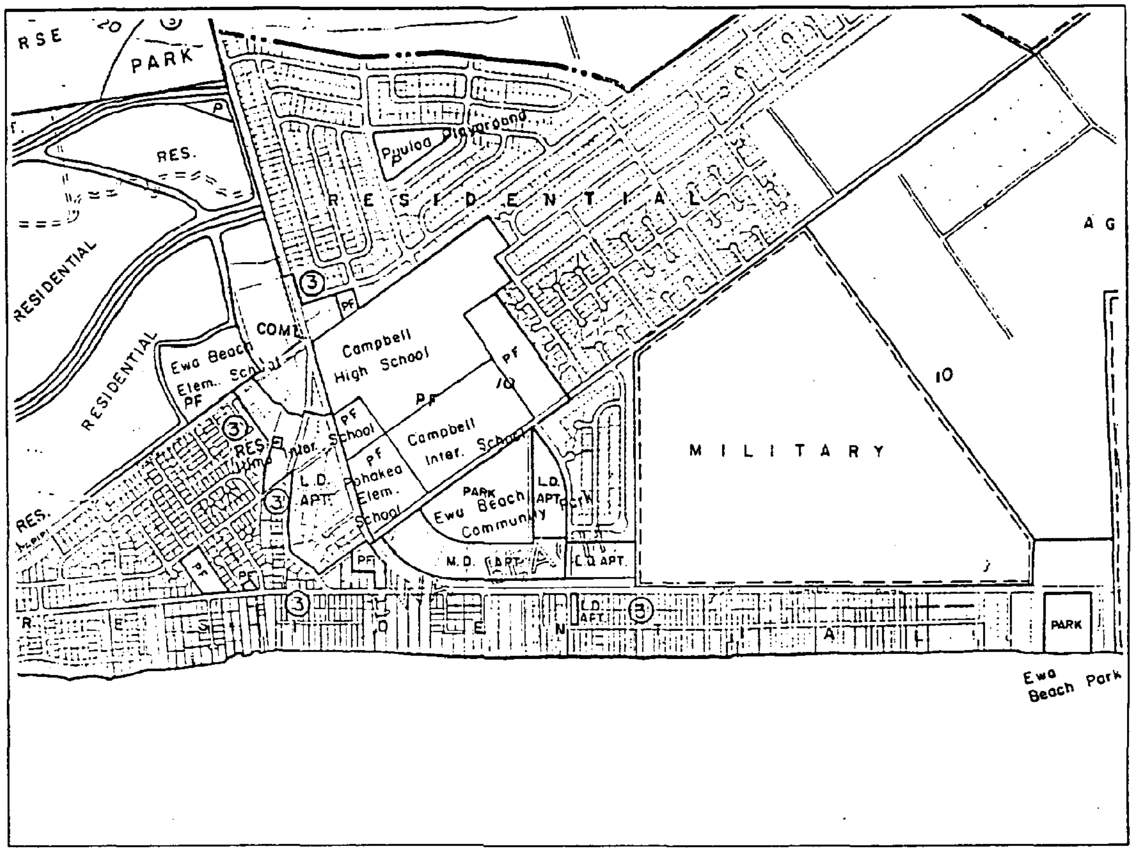


Figure 38. Oahu Development Plan Map for Ewa.

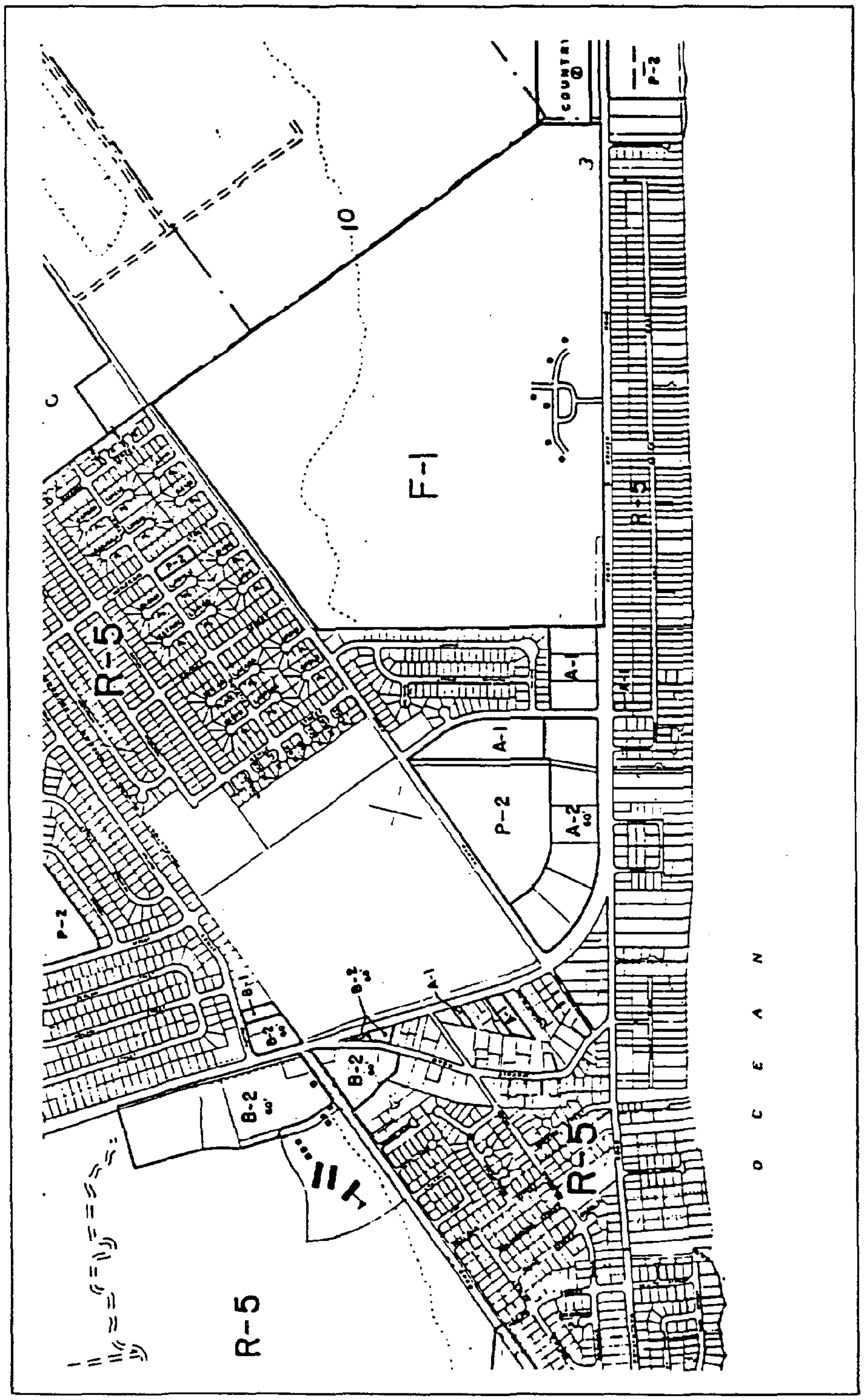


Figure 39. Oahu Zoning Map for Ewa.

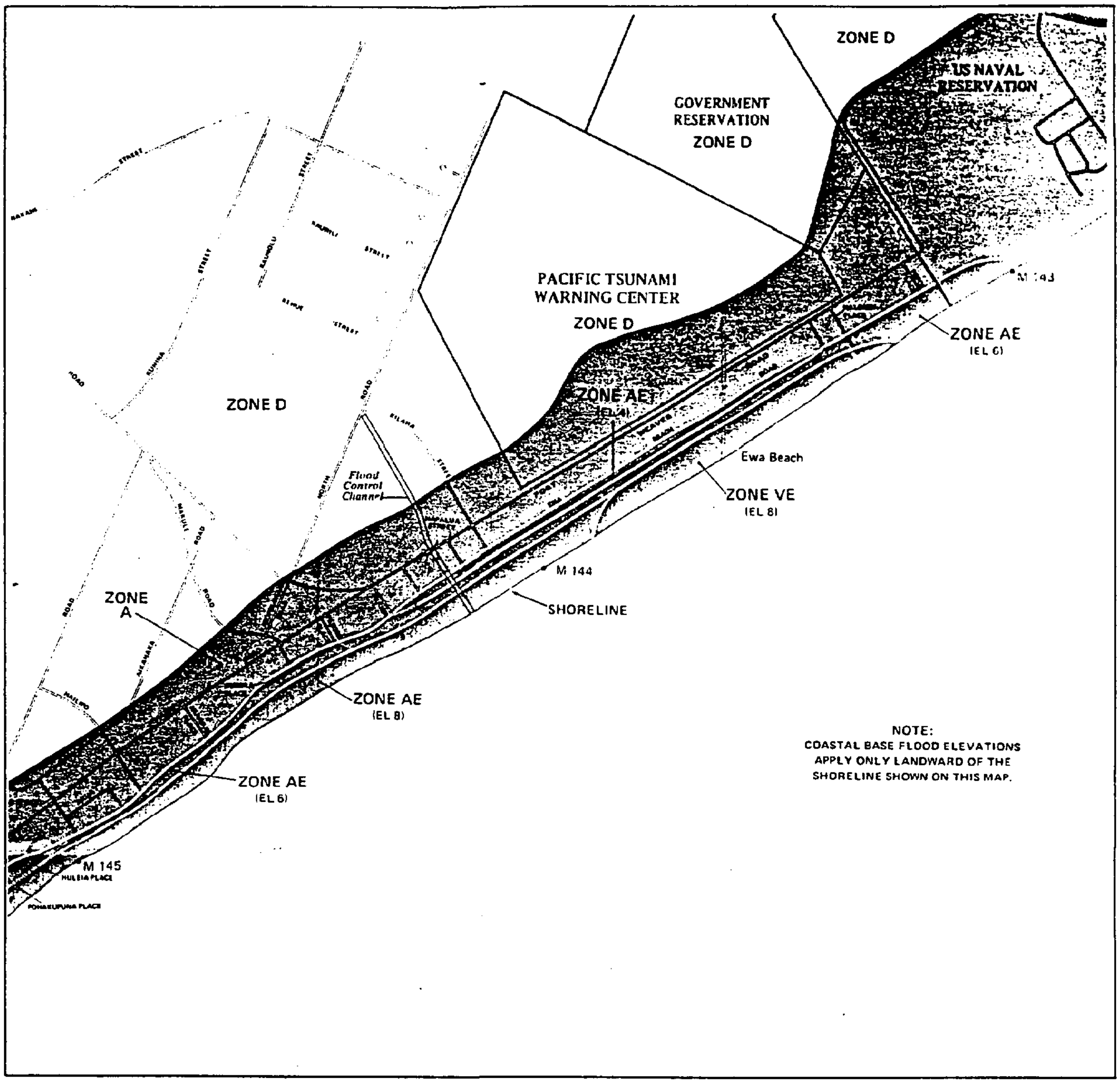


Figure 40. Ewa Beach Flood Insurance Zoning.

population in Ewa. The Ewa Development Plan has targeted new growth in the region. By the year 2010, the population is expected to be between 119,940 to 132,934. This is an increase of 77,000 to 90,000 people. With the increase in population will come an increased demand to use Ewa Beach.

At Ewa, approximately 50% of the jobs are related to the military. About 39% of the jobs are actual military jobs. Another 19% of the jobs are service related. As the Ewa area grows in population, the number of jobs related to the military is expected to decrease.

In 1990, the median price for a owner-occupied home in the Ewa region was lower than in the rest of Oahu. It is unknown what will be the effect on Ewa house prices from new development projects, and the construction of some affordable units.

There is a wide range in the quality, maintenance, vintage and value of the beachfront homes in Ewa. Some of the homes are simple one-story units that are relatively old and poorly maintained. A few houses, most noticeably at the east end of the beach, are newer, with a more elaborate design and well-manicured yards.

4. Physical Setting. The study area is bounded by an emergent reef rock bench to the west and Ewa Beach Park to the east. Offshore, there is a shallow reef platform with water depths ranging from 3-6 feet. The width of the platform is irregular, and ranges from 1,000 to 2,000 feet. The shallow water over the reef limits the wave height acting on the beach.

The area is directly exposed to summer South Pacific swells, local Kona storm waves and infrequent hurricane generated waves. In addition, northeast tradewind waves may refract around Diamond Head, and winter North Pacific swell may refract around Barbers Point to hit the Ewa Beach area. Annual longshore direction suggests Southern Swell has the dominant influence on nearshore wave energy, but other wave types have the potential to erode Ewa Beach effectively. For more details on the characteristics of the different Hawaii wave types, the reader is referred to previous studies (see, e.g., Moberly & Chamberlain, 1964).

The sand at Ewa is generally medium to coarse grained, poorly sorted and predominantly calcareous (Moberly & Chamberlain, 1964). The beach at Ewa is narrow, and portions tend to have a steep profile, especially to the east near Ewa Beach Park.

Longshore sediment transport at the west end of Ewa appears to be towards the west. This is indicated by the erosion and accretion patterns adjacent to a drainage channel that extended perpendicular to the shoreline into the tidal zone. Historic aerial photographs show that this channel acted like a groin, causing accretion on the updrift side (towards the east), and erosion on the downdrift side (towards the west). Because of the influence of the drainage channel, the structure was removed from the tidal zone in 1985.

5. Historical Shoreline Changes. Although the beach at Ewa appears stable (Sea Engineering, 1988), many seawalls have been constructed, thus there is some question regarding the natural erosion or accretion trend on the beach. Homes along this reach were built close to the vegetation line and need the protection of seawalls during periods of high wave or storm activity. Instability along much of this reach may have been greater than normal during the 1958 to 1967 period. During this time, many of the nonconforming seawalls were constructed (Hwang, 1981).

6. Beach Management Problems. By the year 2010, the population in the Ewa region may more than double. This will lead to an increased public demand to use Ewa Beach. While the demand to use the beach may increase, the actual size of the recreational beach may decrease.

Over the years, an ever greater percentage of the shoreline has been spanned by seawalls and revetments. Along the area of interest, there are 118 lots. Of these lots, there are 20 illegal structures, 56 nonconforming structures, 17 legal structures, and 25 lots with no seawalls or revetments. Nonconforming structures are those structures without a permit that were built before 1970. Illegal structures are those structures that were built after 1970 without a permit.

During high tide or high wave activity, the beach is sufficiently narrow that access may be blocked and recreational activity impacted by waves breaking against the seawalls. Along the west end of the area of interest, the beach in front of a span of seawalls is narrow (Fig. 41). Further to the west, one resident reported that the beach in front of his property had disappeared over the last 10 years (Fig.

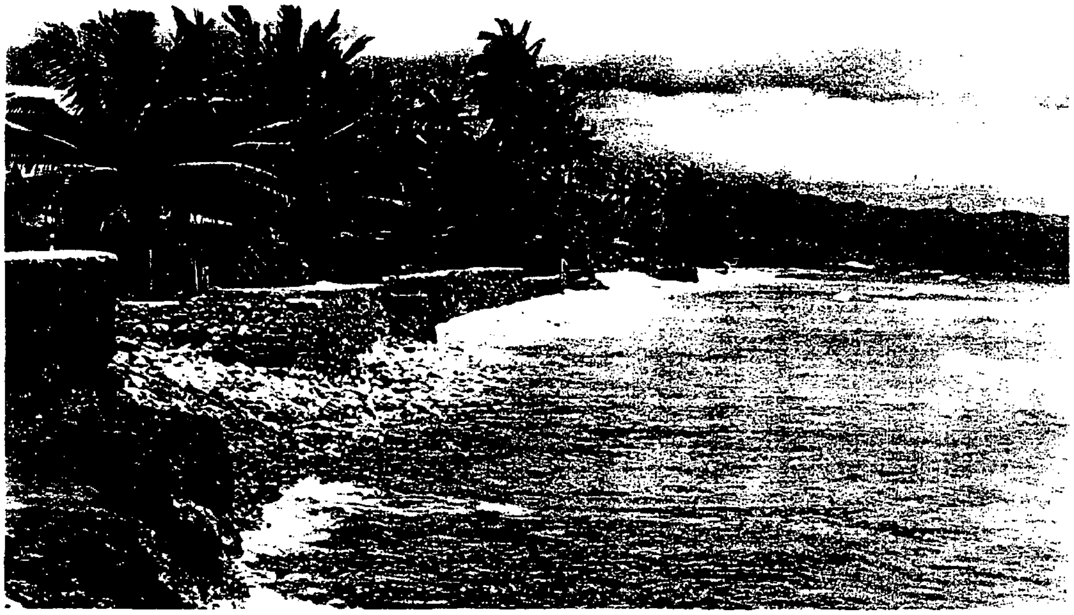

Figure 41. Ewa Beach - West End. Looking east from the west end of Ewa Beach. The beach in front of this span of seawalls has narrowed and is preconditioned for loss. Care must be taken so that beach degradation or loss does not propagate to the east.

Figure 42. Ewa Beach - West End. Looking west from the west end of Ewa Beach. Residents report that in the early 1970's, sections of this shoreline were covered with sand.

42). These problems may become more severe if sea-level rise were to continue or accelerate.

The Department of Land Utilization of the City and County of Honolulu evaluates requests for variances from the shoreline setback law. Variances may be requested for new seawalls or for after-the-fact permits for illegal seawalls. The Department must decide whether to allow the continued proliferation of seawalls and the further degradation of the beach. Alternatively, the Department could deny such variances. Without the proper shore protection, many of the coastal properties would be subject to periodic wave inundation and periodic erosion. The Department turns to the Division of State Beaches for assistance.

7. Alternatives.

a. Sand Replenishment. A Division of Beaches would determine if sand replenishment for the entire stretch of Ewa Beach is feasible. The Ewa Beach littoral cell stretches over two miles in length. The east end of the littoral cell is at Iroquois Point, and the west end at the emergent reef bench opposite Muumuu Place. Such a long stretch may be prohibitively expensive to replenish with State funds. Most importantly, although the offshore reef at Ewa serves to block some incoming wave energy, preliminary indications are that some offshore structures would be needed to contain the replenished sand. This would considerably add to the cost of a project to replenish the entire beach.

It may be possible to divide the littoral cell at Ewa. The City and County storm drainage channel is one likely terminal point. A sand replenishment project that spans the shoreline from the drainage channel to the west end of Ewa Beach may be feasible. Since littoral drift near the storm drain, appears to be to the west, an extension of the channel to act as a terminal groin should not affect the updrift or east portion of the beach. In fact, before the City and County removed the portion of the channel that extended into the tidal zone, there was a slight build up, or accretion of sand, to the east of the channel.

Between the storm drain and the area east of Muumuu Place, a sand fill covering approximately 2,000 feet of the shoreline could be placed. Offshore structures may still be needed to contain the artificial beach fill. The types, amount and cost of offshore structures cannot be determined at this time, since it was beyond the scope of this report to conduct coastal engineering studies at the particular site. Offshore structures, such as a series of detached breakwaters could be very expensive. Offshore breakwaters could cost thousands of dollars per linear foot. With further study, cheaper alternatives to reduce offshore wave energy may be found, thus allowing sand replenishment to proceed along this stretch.

Due to the potential need for offshore structures, a coastal engineering study would be required to develop the sand replenishment option at the west end of Ewa Beach. A proposed Division of State Beaches would have the option to hire a coastal engineer, or conduct the study in house. The study could be paid for by a contribution from a State Beach Fund. Because of the potential need for offshore structures at Ewa Beach, this report developed the replenishment option at Kahala Beach, where preliminary investigations indicate that no offshore structures would be needed.

b. Buried Structures. Sand replenishment at the west end of Ewa Beach does not address the issue of beach degradation versus shoreline protection for the remainder of the area. Clearly, other alternatives are needed for Ewa.

One alternative for the City and County would be to move illegal erosion control structures inland. By moving the structures inland, some protection is given the homeowner while the beach can assume a natural profile (Fig. 43). Just as seawalls in the tidal zone can make the beach narrow, the removal of these walls may allow the beach to reappear.

The City and County of Honolulu, Department of Land Utilization has had some success in requiring landowners to relocate erosion control structures. Along one section of south Lanikai Beach, homeowners had originally constructed seawalls and boulder piles that extended into the tidal zone. These structures resulted in the loss of beach and the blockage of public access. The City and County required the homeowners to remove the barriers and build gently sloping revetments solely on the landowner's properties. By removing the barriers, the beach returned to a natural profile. Recreational use and public access were restored.

This report recommends the use of buried structures such as revetments. The burial of the revetment removes the barrier away from the active swash zone. It should be cautioned, however, that the environmentally beneficial effects of the buried revetment may be temporary. During periods of erosion, the revetment may

Figure 43. Seawalls at Ewa Beach. Where the shoreline has been hardened with seawalls, the beach is narrow and access or recreational use may be limited. Where the shoreline has not been armored, the beach assumes a natural profile, which may be twice the width of the stabilized profile. The construction of buried revetments may give protection to the landowner and allow the beach to assume a natural profile.

Figure 44. Houses at Ewa Beach. Some houses at Ewa Beach are so close to the water line that there would be no room to build a buried revetment.

become uncovered and affect nearshore sediment transport. Nevertheless, the gently sloping buried revetment can be used in conjunction with sand replenishment to provide long-term protection to the landowner while helping to preserve the recreational beach. If a sand replenishment project were to materialize for the west end of Ewa, the existence of the buried revetment would not interfere with the artificial beach fill.

One disadvantage of the buried revetment is the amount of space it takes up along the shoreline due to the gentle slope and multiple layers. For many properties at Ewa Beach, the buried revetment would not be feasible because of the lack of space between the houses and stabilized shoreline (Fig. 44). Some of the properties are less than ten feet from the seawall. On the other hand, there are some homes where the setback is up to 60 feet.

Another problem with buried revetments is the cost. A buried revetment may cost up to $400-$500 per linear foot depending on the specific design (DHM inc., 1990). For an average lot at Ewa Beach with a width of 60 feet, the cost of the buried revetment would range from $24,000 to $30,000. Some of this cost could be substantially reduced if individual landowners were to cooperate by building the buried revetment together.

In order to deal with the illegal vertical seawalls at Ewa, a program can be developed whereby vertical seawalls are converted to buried erosion control structures. For instance, the county could create an overlay district that encompasses all of Ewa Beach. Within the overlay district, the only structures that would be allowed would be buried structures.[7] Specifications can be designed on the types of buried structures that would be suitable, given the typical beach profile and wave regime in the district. The county could then coordinate the activities of adjacent homeowners so that structures are built according to the district design.

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[7] The Department of Land Utilization has received shoreline setback variance applications for the use of buried gravel berms. By increasing the berm height, the potential for flooding or wave inundation of the property is reduced. In addition, there would be no wave reflection off the buried berm, leading to the narrowing or loss of the beach. Care must be taken, however, that if the gravel berm is exposed, the individual stones are not moved by wave action and spread along the beach.

The county could set fines for homeowners who have illegal vertical seawalls. The fine may be based on many factors, including the degree of the violation, the potential impact on the adjacent beach, the value of the properties, the distance of the house from the seawall, or the need for shoreline protection (see Chapter VIII on enforcement). Although, the county agency has some discretion in setting the fines, some degree of uniformity should be strived for. Therefore, the county may wish to develop a formula that relates these factors with the amount of the fine.

For residences that are so close to the shoreline that removal of an illegal seawall could threaten the house, low-level fines of $1,000-$2,000 per year should be considered instead of hardship variances. Money from the fines could go into the Beach Enforcement Fund administered by the county. The Enforcement Fund could then be used to provide subsidies to those landowners who convert illegal vertical seawalls to buried erosion control structures. The subsidy could have maximum limits, such as $7,500, or 20% of the cost of the revetment, whichever is less.

For those landowners who have legal or nonconforming seawalls, no fines would be imposed. However, some of these homeowners may be eligible for the subsidy if they remove their vertical seawall, or convert the wall to a buried erosion control structure. The county could investigate the possibility of varying the amount of the subsidy depending if the vertical seawall removed is illegal, nonconforming, or legal.

The county would work with the Division of State Beaches in at least two ways. First, the Division could help the county develop specifications for buried erosion control structures, such as a revetment or gravel berm. The guidelines would consider the local wave conditions, the type and depth of the substrate, the minimum lot size, and the procedure for the placement of the structures. Second, if the county Enforcement Fund was depleted, the Division could provide, through the State Beach Fund, subsidies to convert vertical seawalls to buried erosion control structures. The coordination between the State and county in providing subsidies for conversion would need to be worked out by the proposed Division.

c. Relocation or Removal. A few houses at Ewa Beach are less than ten feet from the edge of a seawall. For these homes, there is simply no room to build a buried erosion-control structures. Many of these homes have a very narrow beach in front of their properties. In the event of continued sea-level rise, the risk from coastal flooding and wave damage may eventually become intolerable.

If any of these homes are damaged by a storm and or by flooding, the State could offer to purchase the homeowners land with monies from the State Beach Fund. Monies from the Fund could be used to remove damaged buildings, tear down existing seawalls, build flank erosion protection for adjacent properties, and cover the lots with coastal vegetation such as naupaka or hinahina.

Some homeowners at Ewa Beach may be covered by National Flood Insurance. If homeowners were to qualify under the Upton-Jones amendment, they may become eligible for advance insurance payments before there is actual damage to the property. The payments could be used to demolish the structure, or relocate it, if there is sufficient space on the lots. When the insurance payment is combined with a State contribution to purchase the land, significant economic incentive is created for landowners to escape potential problems with erosion. In addition, the public may benefit if the beach were to be recovered.

**B. Kahala Beach.**

1. Location. The beach at Kahala is located along the southern shore of Oahu, between Kupikipikio Point (Black Point) on the southwest and Waialae Beach Park to the northeast (Fig. 45). This distance is approximately 6,500 feet. However, the area of interest for this report is the southwest portion of Kahala where a recreational beach has been lost (Fig. 3). This is a distance of approximately 2,250 to 2,500 feet. This area is covered by tax map keys 3-5-2; 3-5-3; and 3-5-4.

2. Zoning. The Kahala area is designated as Urban on the State Land Use District Map (Fig. 46). The area is zoned for residential use on the Oahu Development Map (Fig. 47). The homes in Kahala are zoned R-5 and R-7.5 (Fig. 48). The R-5 zoning requires a minimum lot area of 5,000 square feet and a minimum lot width of 50 feet for a single family detached dwelling. The R-7.5 zone requires minimum lot areas of 7,500 square feet and minimum lot widths of 65 feet. On the National Flood Insurance maps, Kahala beachfront homes are in the A zone, which indicates there is a threat from coastal flooding (Fig.49).

3. Social Setting. The backshore of Kahala is developed with high priced

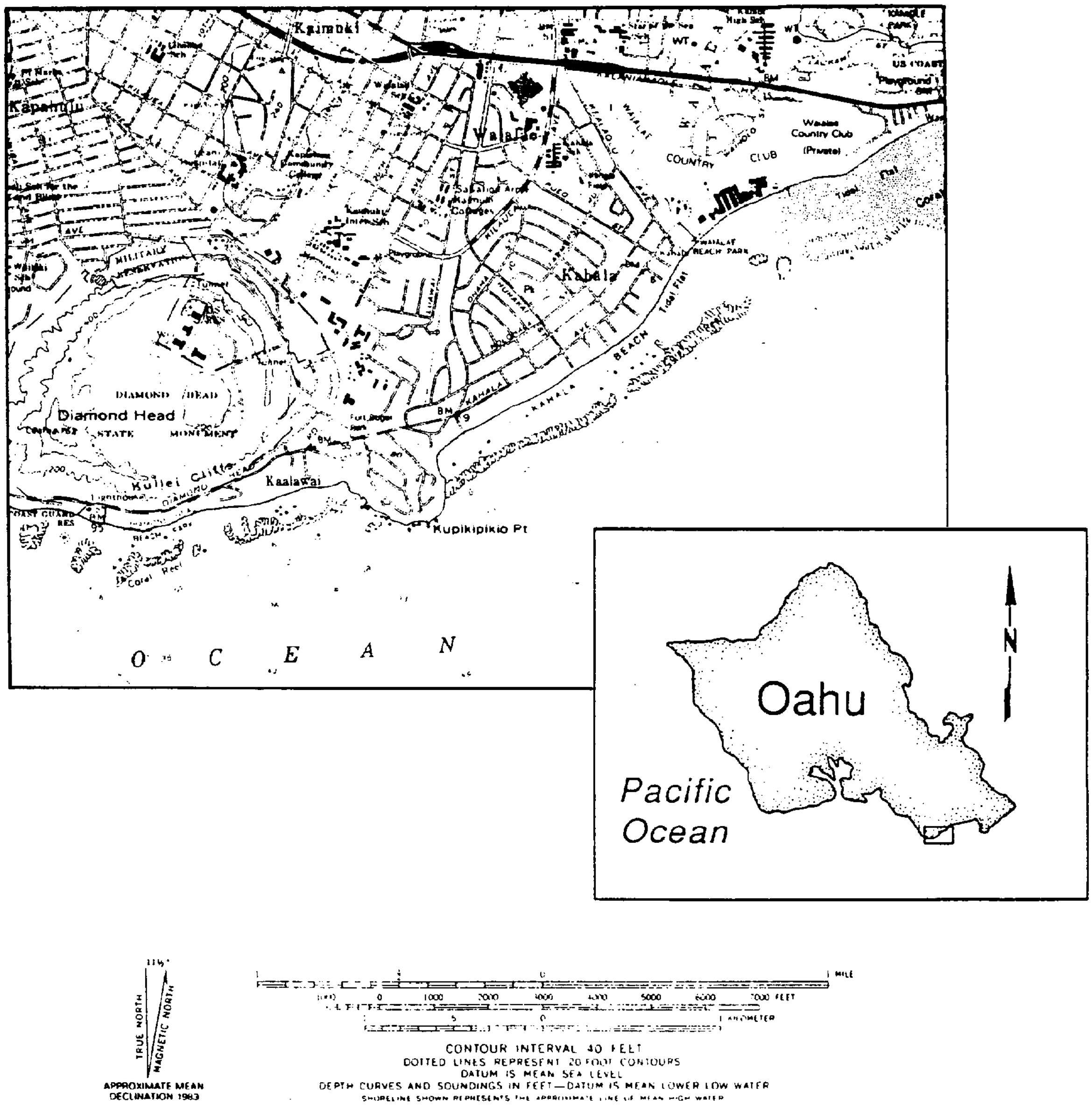


Figure 45. Kahala Beach Location.

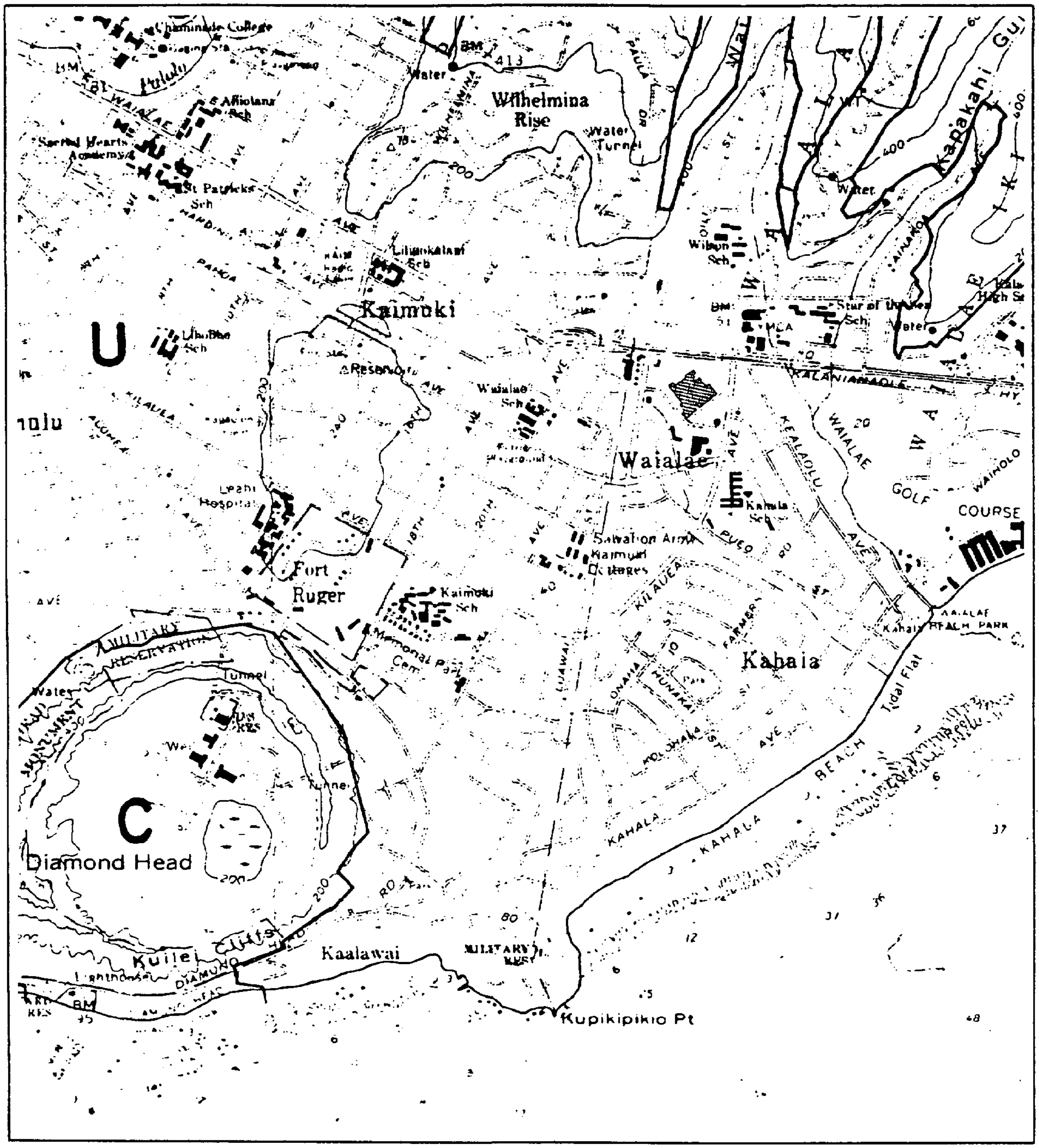


Figure 46. Hawaii Land Use District Map for Kahala.

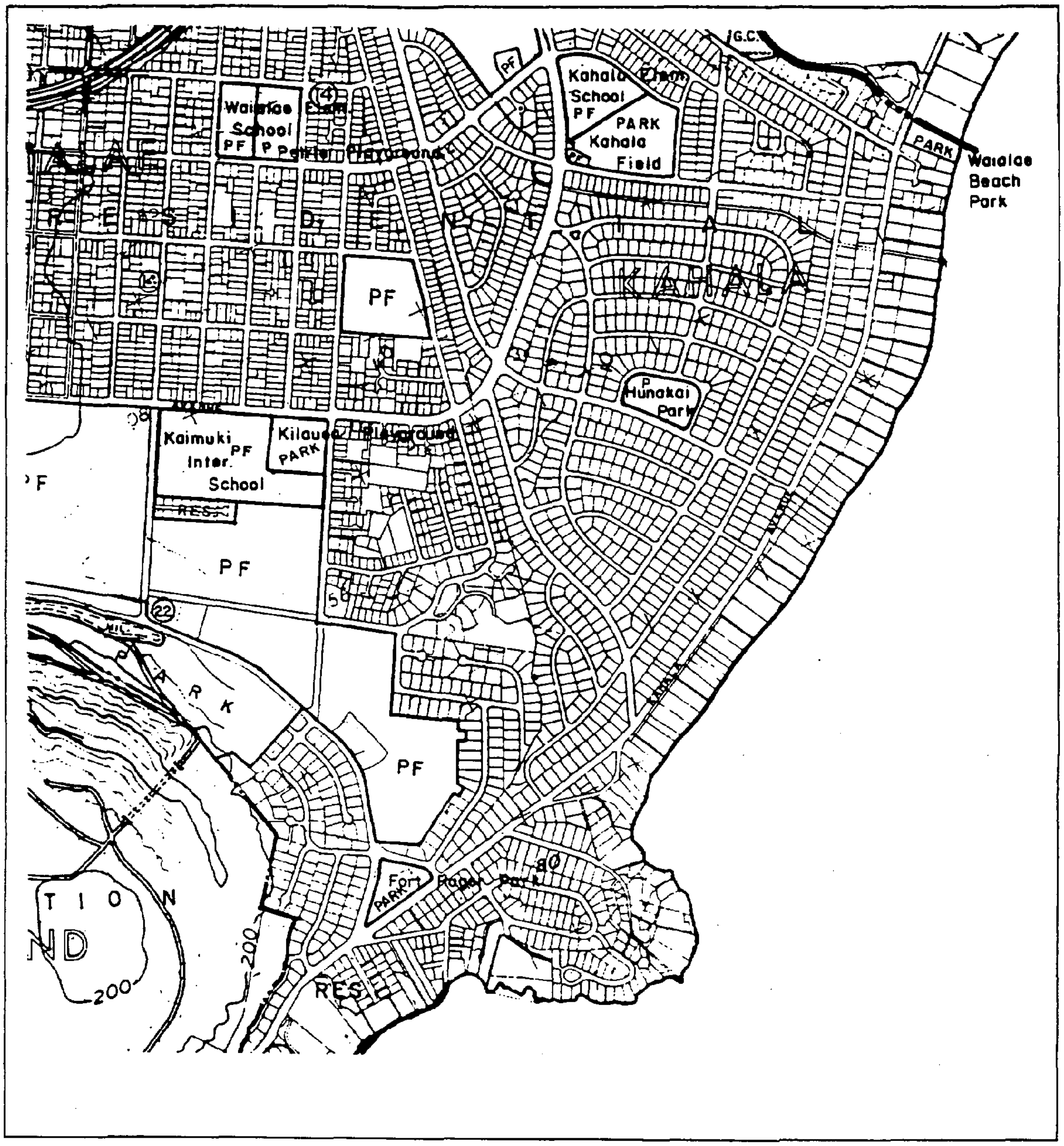


Figure 47. Oahu Development Plan Map for Kahala.

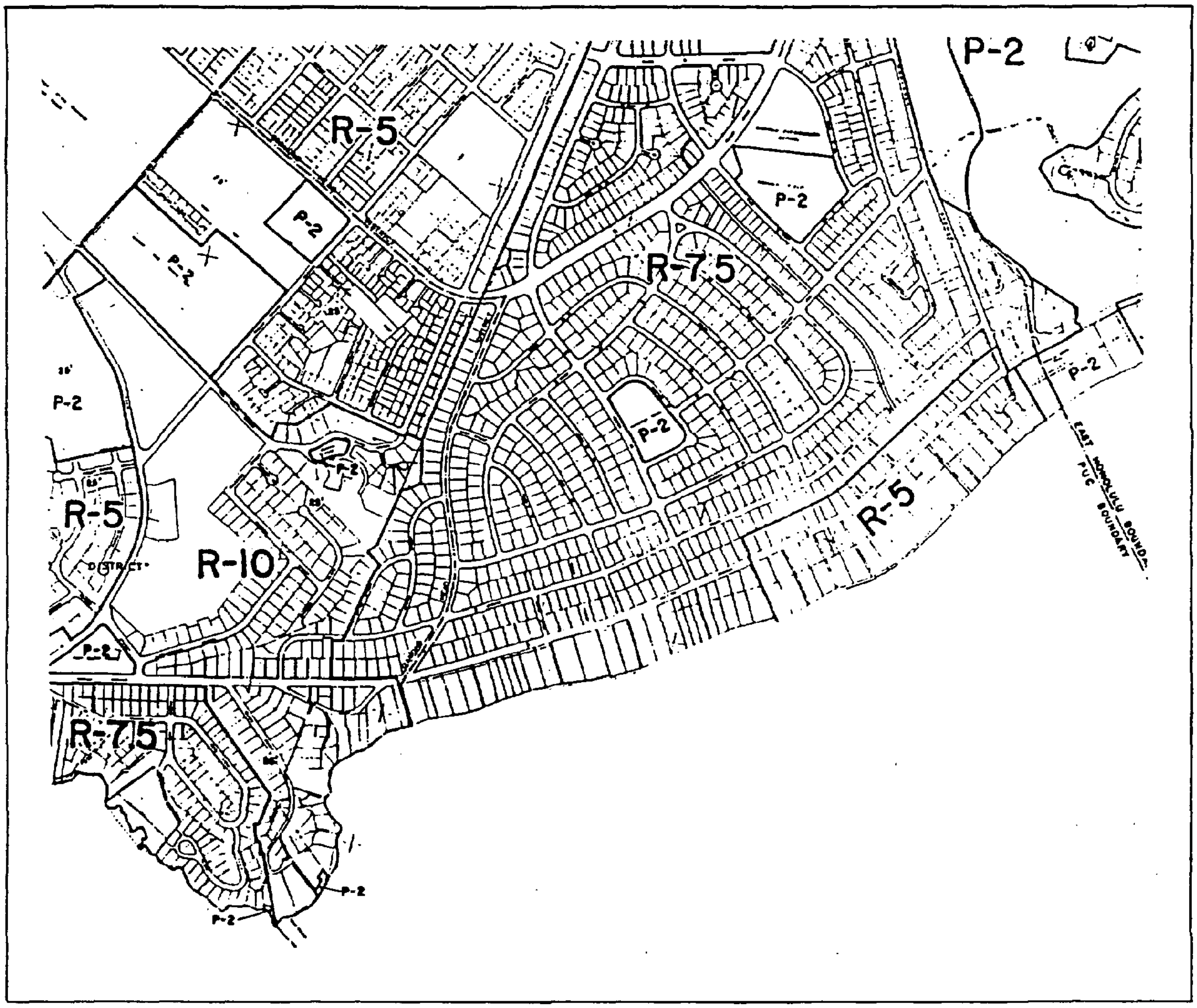


Figure 48. Oahu Zoning Map for Kahala.

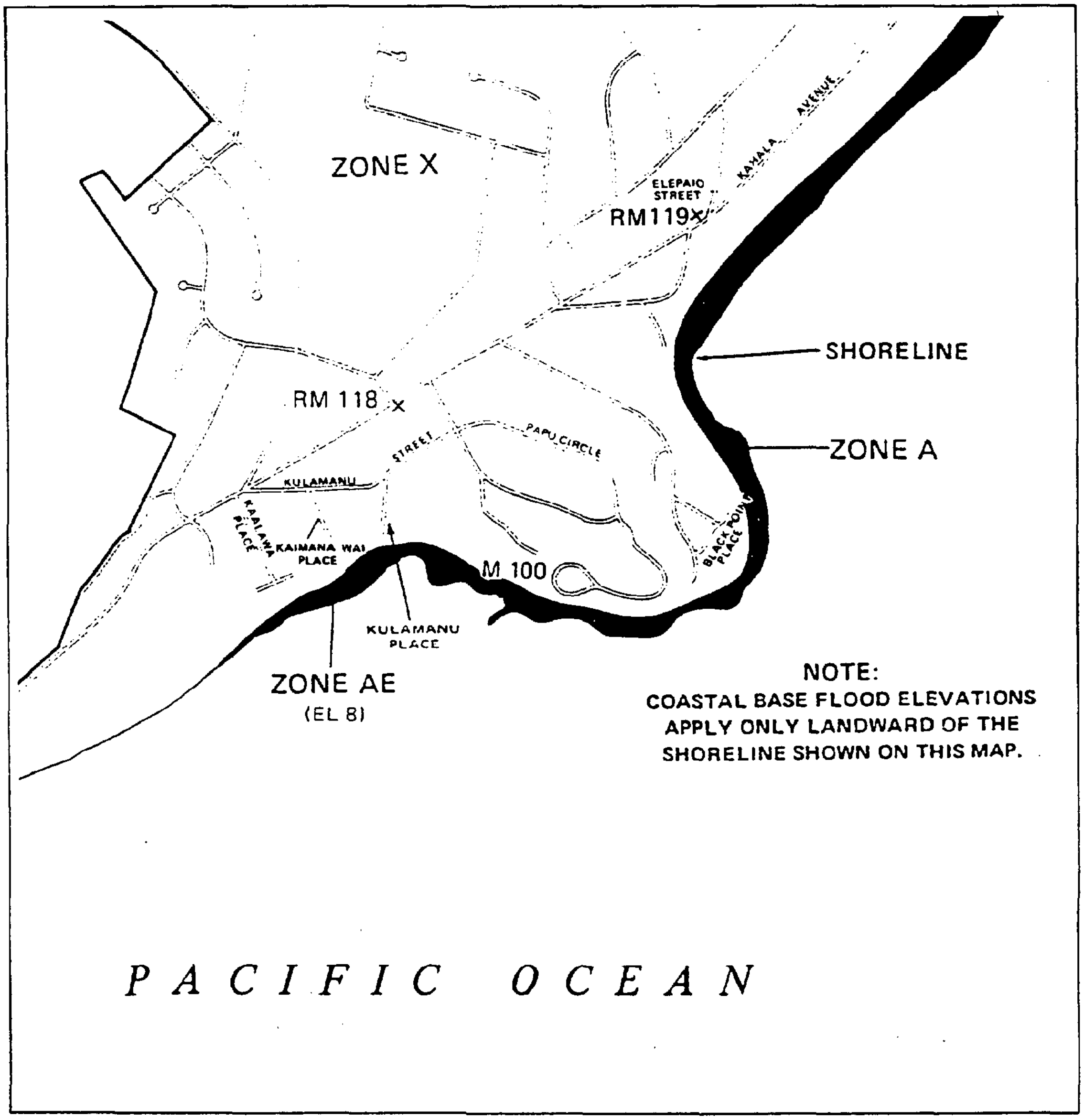


Figure 49. Kahala Beach Flood Insurance Zoning.

single-family dwellings. A recent article in the Honolulu Advertiser, March 16, 1992, reports that at Kahala, a six bedroom, seven bath shorefront house with two adjoining vacant lots was listed at $23.5 million. A six bedroom, seven bath house away from the beach - though not listed - was reported to have a price of $8.9 million.

Although Kahala Beach has the stigma of being exclusive, the beach is not significantly different in terms of public access, or parking to any other beach lined with private homes. At or adjacent to the area of interest, there are three public access-ways. Thus, the requirements of Hawaii Revised Statutes Chapter 115, regarding public access to the shoreline, are met. For many residents of Honolulu, Kahala Beach provides an alternative to the use of Ala Moana Beach Park and Waikiki. It is the only beach easily available to Honolulu residents between Ala Moana and Sandy Beach Park (Sea Engineering, 1991). The beach at Kahala is used for diving, pole fishing, snorkeling, board surfing, swimming and sun bathing.

4. Beach Recovery. There are a number of littoral physiographic features at Kahala that would promote a successful beach restoration project. These include distinct littoral cell termination points, predictable wave climate and sediment transport patterns, a proximal sand source, and a natural containment basin. A sand replenishment project at west Kahala could provide the public with renewed recreational and environmental benefits at a low cost and with relatively few associated sand containment structures.

The wave climate at west Kahala Beach is seasonal with low, long-period southern ocean swell dominating between April and October. These waves typically range between 1 to 4 ft and 14 to 22 seconds, although higher waves approaching 6 ft are not uncommon. When northeast tradewinds weaken and Kona storms develop, high waves and strong winds from the southwestern quadrant may occur at the Kahala coast. Kona storm waves may approach during the winter months with heights of 10 to 15 ft and periods of 8 to 10 seconds. The majority of wave energy is dissipated on the seaward reef crest at Kahala. The reef is consistently shallow in the longshore direction, making it an effective energy barrier for the adjacent beach. Field observations during a period of strong southern swell ranging from 6 to 8 ft. and averaging 15 to 18 seconds at the reef crest, revealed that wave conditions behind the reef vary over a tidal cycle (Fig. 50). At low tide, portions of the back-reef flat are exposed, and wave energy on the beach is negligible. At high tide, wave transformation in the back-reef basin

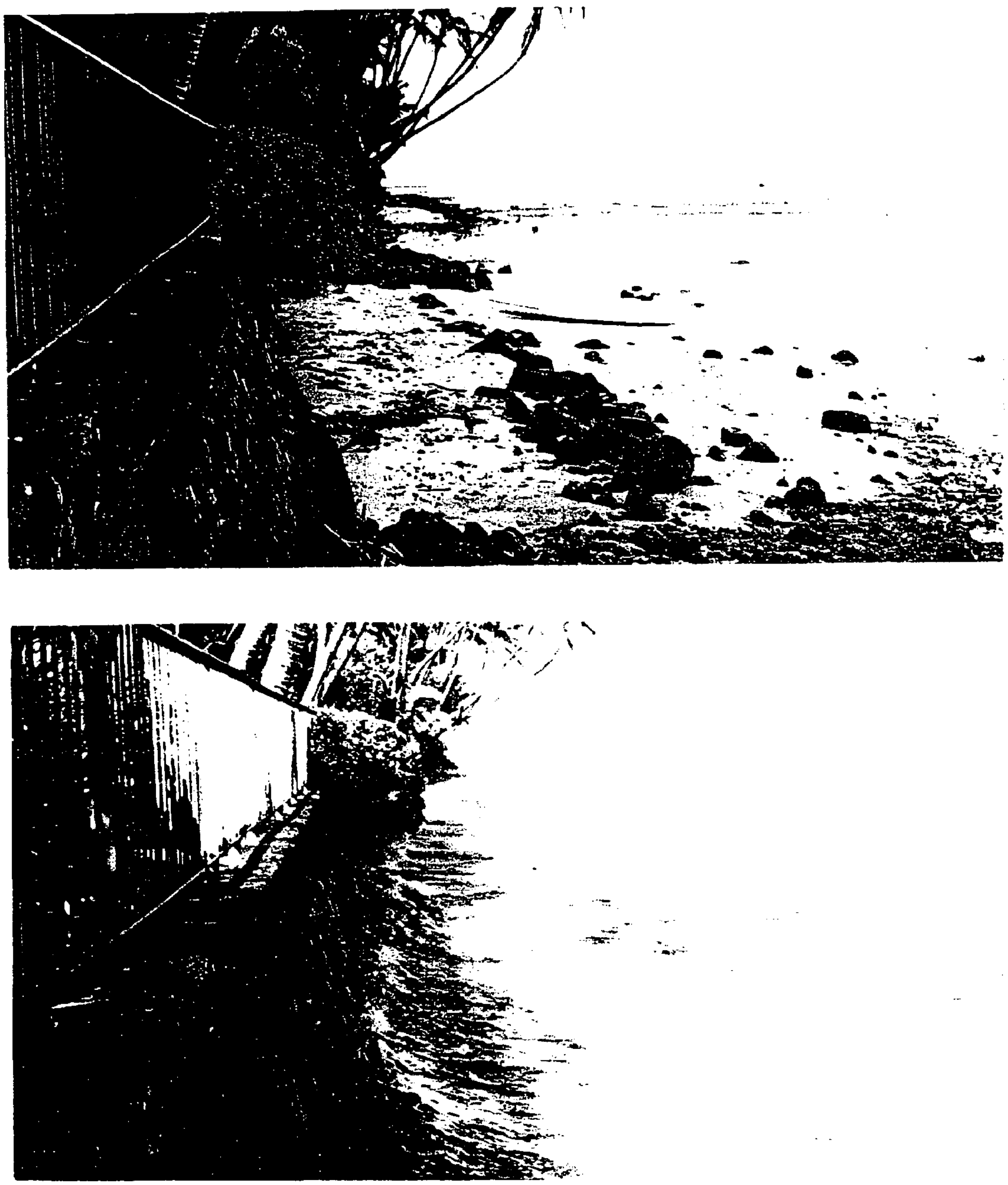

Figure 50. Kahala Beach. **TOP**: At low tide portions of the reef flat are exposed, the waterline is well seaward of the base of existing stabilization structures, and the wave energy is negligible inside the reef crest. **BOTTOM**: At high tide on the same day the waterline has risen to a position well above the base of the seawall and wave energy has increased significantly. Strong southern swell on this day generated breaking wave heights in excess of 6 ft. on the reef crest.

leads to short period 3 to 6 second waves with heights of 1 to 2 feet. In many cases, these secondary waves break directly on the seawalls at Kahala and produce splash heights off the seawalls in excess of 10 ft. These waves appear to have significant erosion potential.

Both southern swell and Kona storm waves approach from the south to southwestern quadrant and generate a northeasterly longshore current at Kahala. This current strengthens to the northeast as it approaches a distinct channel in the reef slightly northeast of Hunakai St (Fig. 51). The reef channel is the primary feature allowing return flow to the offshore region. Currents in this channel were observed to exceed speeds of 3 ft/sec. at peak ebbing tide during high wave conditions. The littoral circulation pattern at west Kahala is driven by wave energy flux across the reef crest and return flow through the reef channel.

Marine sand resource investigations (Coulbourn et al., 1988) identify substantial sand deposits offshore of the base of the west Kahala reef. Sampling of deposits at a depth of 25 ft at the mouth of the reef channel show these to be well-sorted, coarse to very coarse carbonate sands of good color. In the original investigations of Moberly and Chamberlain (1964), sand samples from the berm at Kahala beach measured in the medium to coarse sand range, samples from the beachface at sea level measured in the upper coarse sand range, and samples from immediately offshore of the beach ranged from fine sand to very coarse sand. While further investigations are needed such as described in Chapter VI, at a preliminary level it appears that a potential sand resource for nourishing west Kahala beach may be found immediately offshore of the adjacent reef. These sand fields are not tied to the littoral sands of the Kahala shoreline so that their removal by mining will not effect onshore sand bodies. The marine sand can be most effectively mined by a submersible pump dredge and pumped directly onshore by pipeline. The fill should be desilted by a dewatering cyclone (Noda, 1991) at the discharge end of the pipeline, and the cyclone slurry pumped offshore following careful study of optimal dispersion pathways and currents.

The geometry of the fill should approximate the original 1:7 slope of the beach at west Kahala prior to its loss (Moberly and Chamberlain, 1964). A project length of approximately 2,400 ft is suggested, or from the east side of Kupikipikio Pt. where it meets Kahala beach to the shoreline nodal point adjacent to Ulili St (Fig. 52). The design subaerial beach (horizontal) is 100 ft wide to the berm crest, with a 1:7 offshore slope beyond this point. The fill berm height is 6 ft above msl

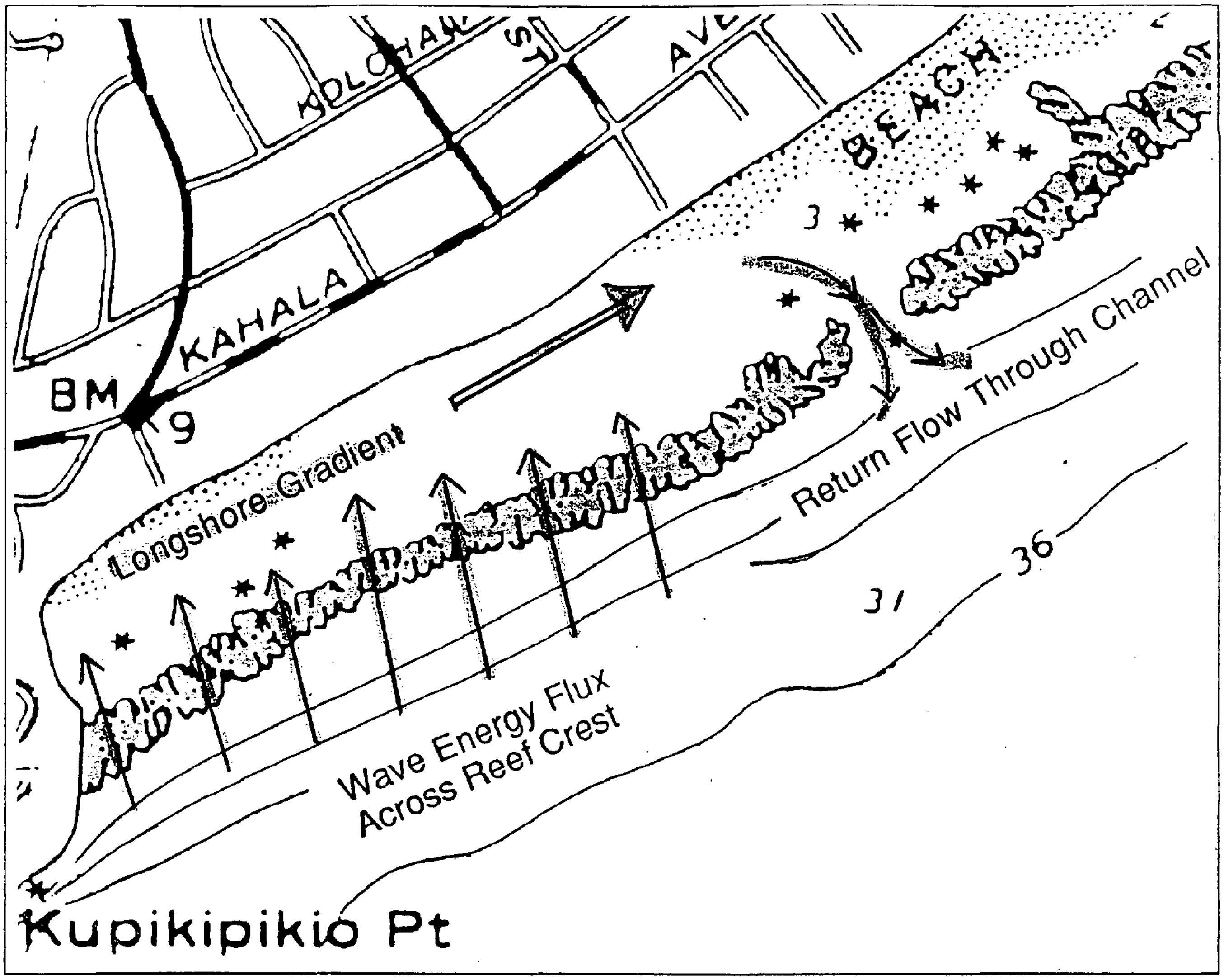


Figure 51. Circulation Pattern. The littoral circulation pattern inside the reef at west Kahala is driven by wave energy flux across the reef crest and strong, channeled return flow through the break in the reef adjacent to Hunakai St. Circulation strengthens to the northeast and approaching high tide.

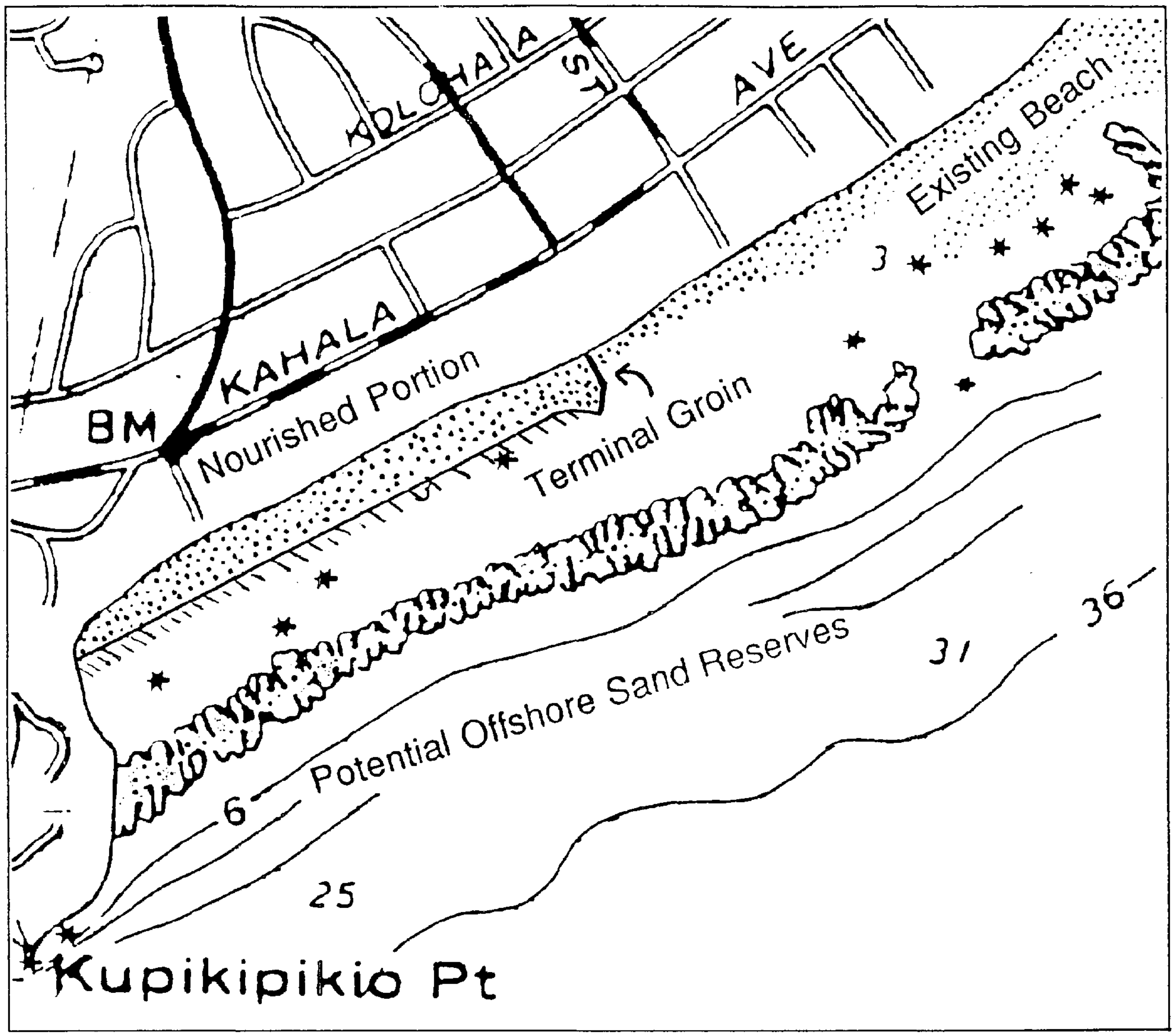


Figure 52. Kahala Beach Nourishment Project. Aspects of the nourishment project including fill geometry, and terminal groin placement.

at 100 ft from the present stabilized shoreline. Subaerial fill thickness is a total of 9 ft which includes a basal thickness of 3 ft of fill to present msl, and an additional 6 ft to reconstruct the subaerial beach to the former berm height. The total subaerial fill volume is 80,000 cu yd (9 ft x 100 ft x 2400 ft). Offshore of the berm, the fill is calculated as a triangle with a slope of 1:7, giving a volume of 25,200 cu yd. This approximates the original beachface planform and geometry in terms of berm height, run-up distance, and waterline position.

These calculations provide an approximate maximum total fill volume of 105,200 cu. yd. Moberly and Chamberlain (1964) measured the sand volume at Kahala. The total offshore and onshore volume was calculated at about 45,000 cu yd. This is a useful minimum total fill volume. Noda (1991) estimates a cost of $12.50/cu yd for marine sands close to the Waikiki project site. As mentioned previously, there is good potential for quality nearshore sands makai of the reef crest at Kahala Beach. Using technology similar to what would be employed at Waikiki, a $12.50/cu. yd. cost appears to be a reasonable estimate for nearshore sand. Based on these figures, the sand fill at west Kahala would cost between $562,500 (min.) and $1,315,000 (max.). Variables influencing this cost include the lack of technological infrastructure in the State for conducting a nourishment project, questions regarding the actual fill volume needed, the overfill factor, and the quality and availability of the sand resource at Kahala. Presumably, costs will decrease if the Waikiki restoration project develops the technological infrastructure that can be used on Kahala Beach. For example, one option at Waikiki that is receiving favor is to use a hydrocyclone to dewater and desilt nearshore sand and pump it on the beach by a pipeline. If the State were to develop this technology and purchase this equipment for the Waikiki project, then any suitable nearshore sand that is identified at Kahala could be placed on the beach with a significant reduction in cost.

Some structural activities are needed in association with sand replenishment. Prior to fill placement, as many as possible of the existing vertical seawalls and steep revetments at Kahala should be removed. If they stay in place, they may eventually begin to interact with the wave environment and cause excessive erosion if there is a storm or hurricane. Once existing structures are removed, the upland should be graded at a 1:3 slope (or less) to the level of the fill. The graded slope should be landscaped with rapid and thick-growing vegetation, and landowners prevented from any construction other than inland of the certified shoreline. Although it is preferable to avoid the use of any shoreline stabilization structures, property owners may be permitted to construct buried 1:3 revetments such that the seaward toe of the structure is located on their property, and the revetment extends landward across private land. The revetment should be buried at all times, and should be reburied if there is erosion that uncovers the structure.

The possibility of installing a low, terminal weir groin at the northeast end of the fill should be investigated. Such a structure may extend the life of the project, and decrease the frequency of renourishment by stabilizing the end of the fill and decreasing the sand loss to longshore drift. Since there is presently no sand on the west Kahala coast, a terminal groin could not interfere with normal sand flux to the northeast. Care must be taken, however, not to extend the groin too far beyond the waterline as some leakage of sand into the littoral system should be encouraged to help maintain the beach to the northeast. Studies should also determine the optimal orientation of the groin, and the benefits derived from curving the tip to the southwest to provide additional stability. The groin should be low enough that the onshore portion is buried by the fill, and that the offshore portion does not present a safety hazard.

As calculated in Chapter VI, the Bruun Rule estimates for Oahu suggest that, under current rates of sea-level rise, the nourishment project will experience recession of 4.6 ft/dec; for projected rates of sea-level rise next century, recession may occur at 18 ft/dec. Under present sea-level rise the renourishment requirements for the southwest end of Kahala will be about 1073 cu yd/yr, which equals an expense of $13,415 averaged annually. This recession rate and the attendant expenses are based on sand losses due to sea-level rise only. Storms and high wave events will inevitably accelerate the recession rate and increase the costs. The average annual costs for renourishment due to sea-level rise will fall somewhere between $13,415 (present sea-level rise rate) and $52,703 (projected future sea-level rise rate). Thus, escalating costs for maintaining the beach should be expected in connection with the potential for accelerating sea-level rise in coming decades. In addition, these costs should be increased by an unknown factor to compensate for storm and high wave erosion.

A number of considerations should be addressed prior to implementation of the west Kahala beach nourishment project. These are:

a. Careful sampling of the offshore sand source at Kahala to determine fill volume, grain settling velocity characteristics, sorting and silt content, and cementation.

b. Modeling of the equilibrium beach profile under the seasonal wave climate using native grain characteristics, and also with the characteristics of the potential fill sand from offshore.

c. Determination of historical storm frequency and magnitude at west Kahala, and estimates of the impact of storm events on renourishment needs and scheduling.

d. Monthly profile surveys of the existing beach at east Kahala to determine annual beach volume changes and their causes and littoral transport patterns.

e. Consideration should be given to the potential for water column siltation and associated impacts to the adjacent reef community.

Finally, it is of critical importance to the success of both this and all other nourishment projects in the State that the fill be regularly, frequently, and precisely monitored over the long-term in order to fully assess the factors governing stability, economic viability, and response to sea-level rise and wave parameters. The State needs to build an empirical database to make accurate predictions on fill life and performance. In addition, the science of predicting beach response to sea-level rise presently lacks a high-precision, long-term database for developing more sound numerical models based on oceanographic conditions. Monitoring must consist of a detailed onshore and offshore component, an accurate description of wave climate, and regular calculations of beach volume and surface area changes with corresponding data on the hydrodynamic and meteorologic field.

5. District Formation. In order to recover the beach at Kahala through sand replenishment, a Beach Management District would need to be formed using overlay and improvement district concepts. The exact boundaries of the district could be determined at a later date, when additional coastal studies define the terminal boundaries of the artificial beach fill. The approximate district boundaries would be at the intersection of Kahala Beach with Kupikipikio Point and the nodal point at Kahala Beach opposite Ulili St. The northeast part of the Kahala Beach Management District would be a zone that marks the transition from the artificial beach to the southwest with the natural beach to the northeast.

The district is expected to cover a distance between 2,200-2,400 feet. There are approximately 25-27 lots along this stretch. The exact number of lots can be determined after the terminal points of the beach fill are calculated. Data from the

Department of Land Utilization (DLU) indicates that of the lots along this stretch, approximately 28% have legal seawalls and revetments, 32% of the structures are nonconforming, and 40% are illegal. Depending on the legal status of the erosion control structure, there may be different opportunities and constraints regarding district formation, fines, and the removal of the structures (Table 8).

If a sand replenishment project were to materialize at Kahala, one of the first steps of the DLU would be to initiate the formation of an overlay district. In the district, landowners would be required to remove illegal vertical walls and steep revetments. A fine could be placed on illegal structures, with the monies going into a county enforcement fund. The fine should be based on numerous factors such as the degree of the violation or the impact on the beach. An additional factor that should be considered in setting the fine is that the area is being prepared for a sand replenishment project. The presence of the illegal vertical seawalls could result in the seaward transport of artificial sand.

Substitute erosion control structures such as buried revetments may be allowed for homeowners that remove their seawalls. By converting the vertical walls to buried structures, the shoreline is prepared for sand replenishment at a later date. As in the example for Ewa, subsidies from the County Enforcement Fund, or the State Beach Fund could be provided to help in the conversion.

For legal or nonconforming seawalls, there is no mechanism to require homeowners to remove the vertical walls. However, for nonconforming structures, it may be possible to phase out the use of the nonconformity with a retirement or amortization schedule. This process could take many years, and may delay the formation of a district.

Incentive to remove legal and nonconforming vertical seawalls and convert to buried structures is provided in several ways. First, subsidies could help landowners make the conversion. The administering agency could consider granting a larger subsidy for legal and nonconforming structures as compared to the subsidy for illegal structures. Besides economic incentive, there is another reason for landowners to convert. Many of the vertical walls along the beach could be undermined (Fig. 53). As sea-level continues to rise, collapse of the walls may become more common. The effect of a water level rise on the gently sloping beach at Kahala has been shown previously (Fig. 50). From the perspective of long-term property protection, the landowner may have more protection with a gently sloping

Table 8 - Legal Status of Erosion Control Structures.

| Legal Status | Fines | Removal | Forced Compliance (BMD) |
|---|---|---|---|
| Illegal | Fines can be imposed. HRS 205A-32 provides for a one-time fine of up to $10,000, and/or a $1,000 per day fine for SMA or Shoreline Setback violations. | Any illegal structures in the shoreline setback area without a variance can be removed (HRS 205A-43.6). | Must comply with overlay regulations regardless of legal status. |
| Nonconforming | No Fines | No immediate removal. Structures can be phased out according to an amortization schedule for commercial, industrial, resort, and apartment zoned areas. No amortization for existing single family buildings or premises (HRS 46-4). It is unclear if a seawall is part of a building or premise. Other coastal states have amortization schedules for the removal of seawalls. | If the majority of landowners consent to the formation of an improvement district, then the holdouts can be forced to comply. This is usually enforced by placing a lien on the holdout's property.<br><br>No regulation was encountered that forced compliance as a penalty for illegal activity. It appears that compliance may be obtained indirectly. (See next section on landowner cooperation). |
| Legal | No Fines | No immediate removal. However, new rules can be passed that make legal structures nonconforming. | No forced compliance to sign an indemnity agreement regardless of legal status. An indemnity agreement is a contract that requires volitional consent of the parties for proper formation. |

buried revetment that has a well maintained artificial beach in front. Finally, a restored beach at Kahala would enhance recreational opportunities and improve

Figure 53. Seawalls at Kahala. **TOP**: During low tide, the effects of wave attack can be seen at the base of seawalls. **BOTTOM**: At the northeast end of the area of interest, this seawall collapsed due to the undermining of the base by wave action.

scenic views, thus adding to the value of the coastal property. These benefits would need to be conveyed to the landowners.

The possibility exists that a number of vertical seawalls along the stretch of Kahala Beach cannot be removed. One solution would be to form the district only for those sections of the shoreline where the seawalls are removed. Alternatively, the project could proceed with some offshore barrier that reduces wave energy before it reaches the vertical seawalls. This would add cost to the overall project, and require further coastal study. In addition, while the nonconsenting landowners may legally refuse to remove their seawalls, they may not refuse to pay for improvements that benefit their property. Therefore, the landowners actions would increase their cost in the project as well.

6. Landowner Cooperation. In order to finance a sand replenishment project, an improvement district would need to be formed. The improvement district would require the consent of a certain percentage of the shoreline property owners.

The presence of illegal shoreline structures may provide some opportunity for the State to procure landowner consent to join an improvement district. In a survey of coastal statutes for different states, no provision was found that forced cooperation in an improvement district as a penalty for illegal activities along the coast. Nevertheless, it may be possible to obtain landowner consent indirectly. For example, the counties may force the removal of illegal vertical seawalls (HRS 205A-43.6). The types of erosion control measures along the shoreline to those that require the implementation of a district. Thus, incentive can be created for the landowner to join the district in order to mitigate erosion of their property. In addition, the State has the power to fine illegal activities (HRS 205A-32). Fines for the illegal activity can be used to pay for the improvements in a Beach Management District.

It would be the Division of State Beaches that develops rules and criteria for the formation of a Beach Improvement District. One set of rules would deal with the level of landowner cooperation to form an improvement district. This report suggested setting the initial level at 80% to reduce the problem with nonconsenting landowners (the Oahu improvement district ordinance requires a 60% level of cooperation). Where liability may be high, 100% landowner cooperation may be required. The Kahala sand replenishment project would not be considered high risk since the properties are likely to have some structural barrier, such as a buried revetment, behind the artificial beach fill. If the beach were to disappear, the barriers could provide emergency protection.

If 80% of the landowners do not approve of the improvement project, then the Kahala replenishment project would be rejected by the Division of State Beaches. Assuming 80% of the landowners approve of the project, this analysis will proceed.

7. Cost Allocation. As discussed in section 4 on beach recovery, the cost to replenish the west end of Kahala Beach will range from $562,500 to $1,315,000 depending on the actual size of the beach fill. This cost would be shared, in different amounts, by the State, the county, the landowners and possibly the Federal government.

a. Federal. Under the Rivers and Harbors Act, Federal assistance is available for small erosion control projects that benefit the public and the private sector. The amount of the Federal assistance is to be adjusted depending on the degree of public benefit. The contribution is not to exceed one-half of the total cost of the project. Thus, there is the requirement that the State or local government provide matching funds.

Assuming Hawaii was eligible for such benefits by establishing a funding mechanism similar to that discussed in this report, then the Division of Beaches would actively seek such assistance for all replenishment projects. For discussion, it is assumed that the Division of State Beaches has petitioned the Secretary of the Army for Federal assistance and was able to procure a contribution of $250,000.

b. Landowner. For the improvement district, landowners are also assessed a portion of the cost. The landowner assessment ranges, as suggested in this study, between 30% to 45% of the cost, depending on the amount of public benefit. For this section of Kahala, the landowners are assessed 45% of the total cost. The landowner assessment could have been lower if there was better public parking. The assessment could have been as low as 30% if the project site was adjacent to a pubic beach park.

The landowners cost is adjusted for any Federal contribution. In this example, the landowners at Kahala must pay 45% of $312,500 to $1,065,000.00. Therefore, the landowner's fractional cost would be between $140,625 and

$479,250. Divided between approximately 26 homes in the District, <u>the average amount each landowner would pay would range from $5,409 to $18,433</u>. However, the exact amount each landowner would pay is based on an assessment formula that includes, as one factor, the linear footage along the shoreline. The narrowest lot along this stretch spans 10 feet of the shoreline while the widest covers almost 100 feet. For the narrow lot, the assessment would be between $611 to $2,084. For the widest lot, the assessment would be between $6,114 to $20,837.

Individual landowners could be given the option of contributing more than their assessment into the State Beach Fund to receive a State tax deduction. Such a program may lead to pleasant surprises in the amount of contributions received by the assessed landowners.

c. County. County cost would be between 10%-20% of the total cost of the project less any Federal contribution. If the counties were to cooperate with the State and grant a 1% to 2% reduction in property assessments for beachfront homes that are in compliance with all regulations, then the State could pick up a greater share of the cost. In this instance the county contribution would be 10% of the total cost, or $31,250 to $106,500.

d. State. The State would pay 60%-45% of the cost, less any federal contributions. The amount of the State payment will be dependent on the public benefit of the project. For the Kahala example, the cost to the State would be 45% of $312,500 to $1,065,000. This would amount to $140,625 to $479.250, taken from the State Beach Fund.

In Table 9, there is a breakdown of costs for the State, the county, and the landowners using several scenarios. The high cost estimate assumes a beach fill of 105,200 cubic yards of sand, a price of $12.50 per cubic yard and no Federal contribution. The low cost estimate assumes a beach fill of 45,000 cubic yards of sand, a price of $12.50 per cubic yard and a Federal contribution of $250,000. Using the high cost estimate in column 1, the <u>average</u> landowner's contribution would be $22,760. It should be noted that this cost is less than the $39,600 cost to build a buried revetment (Assuming an average lot width of 88 feet and the cost of the revetment at $450/linear foot).

Table 9 - Breakdown of Costs for Kahala Beach Sand Replenishment.

| Party | Hi Costs No Fed. Contrib. | Hi Costs Fed. Contrib. | Low Costs No Fed. Contrib. | Low Costs Fed. Contrib. |
|---|---|---|---|---|
| Each Landowner | $22,760 | $18,433 | $9,736 | $5,409 |
| County | $131,500 | $106,500 | $56,250 | $31,250 |
| State | $591,750 | $479,251 | $253,125 | $140,625 |

For the City and County of Honolulu, there would be a cost of $131,500 to pay for their share in the Beach Management District. This is not much, considering the close proximity of Kahala Beach to the residents of Honolulu.

Finally, the State share for the replenishment project would be $591,750. Interestingly enough, the revenue from the sale of a 15 million dollar home in Kahala can generate income of $300,000 from the 2% shoreline property transfer tax. This money goes into a State Beach Fund, which can be used to pay for the State contribution to replenish Kahala Beach. The money from the transfer tax would pay for half of the State contribution. Thus, when a shoreline property is sold, revenue that is generated can be used to benefit the existing beachfront homeowners, the State, the county and the public.

With the projected acceleration in sea-level rise, the annual cost to maintain the beach would be $52,703 per year. Before a district is formed, an agreement would be needed between the State, counties and landowners on a maintenance schedule, and the allocation of costs. Some coastal states require that landowners are entirely responsible for maintenance cost. Assuming landowners are made responsible for maintenance, when the annual cost is divided by 26 properties, there is an average cost of $2,027 to maintain the beach. These costs are very reasonable considering the value of the property protected.

It is believed that many of the costs could be significantly reduced if a State office was established to develop the technological infrastructure to conduct continuous sand mining operations.

# XI. RECOMMENDATIONS

In this report recommendations are made that fall into three categories. First, there are recommendations related to the implementation of Beach Management Districts at the State and county level. Second, there are recommendations related to the two case study sites at Kahala and Ewa Beaches. Finally, there are recommendations related to beach management in general.

## A. Beach Management Districts

<u>This report recommends the use of improvement and overlay districts to help in the management of the State's beaches.</u>

The Hawaii Land Use Enabling Act gives the counties the authority to establish both overlay and improvement districts. In Kauai County's Zoning Ordinance, there is a provision for overlay Shore Districts. In these districts, there are restrictions on seawalls and bulkheads. The district ordinance requires the use of sloping permeable revetments when barriers are permitted. Although the Shore District ordinance was passed in 1972, Kauai has yet to implement the concept.

The overlay shore district would give the counties discretion in protecting sensitive or unique areas of the coast. The overlay district may be useful for undeveloped coastlines, since additional restrictions may be placed on highly unstable areas. For developed coastlines, the utility of the overlay district may not be as great since the landowner may still be limited to the use of seawalls and revetments. Nevertheless, the overlay district may give the counties the discretion to regulate the types of erosion control structures along the shoreline. Given the extent of the erosion problem, some type of erosion control regulation should be considered at the State or county level.

It is through the improvement district that alternatives other than seawalls and revetments can be developed for the landowner. The individual counties may establish improvement districts by adopting an improvement ordinance similar to Oahu's, or by modeling the ordinance after other coastal States. Nevertheless, some of the counties may not be organized technically or financially to establish the types of improvements that may be included in the district.

<u>It is recommended that an agency within the State be established to promote</u>

and administer Beach Management Districts. Although, the exact procedures would need to be worked out by the State agency, the following are recommended as preliminary guidelines to pay for improvements in a Beach Management District.

Formation. Provisions should be considered that allow the formation of a district upon the petition of a State or county agency, or a group of landowners, or the public. Regardless of the party that submits the petition for district formation, a minimum level of landowner consent would still be required.

Cooperation. There are many reasons for landowners to join an improvement district, including increased property value and shoreline protection. For this reason, the initial level of landowner cooperation should be made high. A preliminary suggestion is that 80% of the landowners in the district agree to the project. If the project is one of higher risk or liability, then 100% cooperation is suggested. For a high risk project, the State should not form a district unless 100% of the affected landowners sign an indemnity agreement. A high risk project may be one in which the property owners rely solely on sand replenishment for property protection.

Assessments. The assessment formula should include as a primary factor the linear footage along the beach. Other factors such as value of the protected property may also be considered, if there is a wide disparity in the quality, vintage or value of the beachfront homes. If there is a wide range in the distance of the structures from the shoreline, this factor may be considered in the assessment.

Cost Allocation. A shared cost system is recommended, with the State, counties and coastal landowners paying for the nonfederal portion of the total cost of the project. A preliminary allocation of costs is State 60% - 45%, county - 10%, and beachfront landowner 45% - 30%. The exact costs for the State and beachfront landowners would be dependent on the degree of public benefit derived from the project.

Liability. All homeowners who agree to the formation of a BMD should be required to sign an indemnity or hold harmless clause which relieves the State and county from any liability for the failure of an erosion control structure. To reduce liability from the public, the State would need to periodically monitor improvements within the district for dangerous unnatural conditions.

Monitoring. Periodic monitoring would be required to check on the status and condition of improvements within the district, and to check on the performance of artificial beach fill.

Maintenance. Any improvement district which involves sand replenishment should not be approved without a long-term commitment to periodic renourishment. The schedule and allocation of costs would have to be worked out by the State, counties and landowner.

**B. Beach Management**

State Role. This study reports formidable problems along the beaches of Hawaii. Scientific evidence indicates these problems will intensify in the absence of an active role by the State. The State is the trustee of the beach resource. The State should take the lead in defending against coastal erosion and sea-level rise. It is recommended that the State establish an agency that is responsible for the management and administration of beaches. The agency would develop and implement many of the programs outlined in this study, as well as any other programs that provide for the maximum long-term societal benefit from the beach resource.

Public Education. It is essential that the problems with beach loss, erosion and sea-level rise be conveyed to the public. It is peculiar that despite the widespread degradation of the shoreline, there are many who feel further protection of the coast is unnecessary. A public education program should objectively convey the facts about the coastline to landowners, buyers, sellers, developers, planners, engineers, government officials, elected officials and the general public. Without an informed public, it will be difficult to implement the changes in shoreline management which are required.

Zoning. Although attempts have been made in the past, the State should make another effort to modify the shoreline setback. Using the guidelines and programs discussed in Chapter VIII, the economic burden to landowners can be minimized or eliminated, thereby reducing political opposition. Furthermore, amendment of the setback as proposed facilitates future participation in Federal programs under the River and Harbors Act and the National Flood Insurance Act. The former Act may help in the financing of a Beach Management District, while the later can offer a degree of financial protection to the landowner. A properly structured setback, that is no more burdensome than necessary, is the most efficient way to ensure the preservation of the beach resource and the protection of private property.

Research. Further research should concentrate in two areas. First, a program of continuous monitoring should be developed using beach profiles and aerial photography to help planners and administrators make informed beach management decisions. Second, offshore sand sources that are adjacent to eroding beaches may be the best opportunity to provide a cheap source of replenishment sand. However, there are many technical, economic, environmental and legal issues that need to be resolved. For example, research may be needed on the impact of sand mining on coral reef communities. Methods to mitigate any potential impact, such as the development of special equipment, should also be investigated.

### C. Ewa Beach

The City and County of Honolulu should establish an Enforcement Fund. Income into the Fund would be derived from fines for shoreline setback violations and from legislative appropriations. Money from the Fund could be used for enforcement activity and to pay for subsidies to convert vertical seawalls to buried erosion control structures landward of the certified shoreline. An overlay district could be formed that allows only a certain erosion control design in the district. A strategy of fines and subsidies can be used at Ewa Beach. For those residences that are so close to the shoreline that removal of the illegal seawalls would threaten the property, the use of low-level fines, on the order of $1,000-$2,000 per year should be considered. Where the residence is further from the shoreline, the fine could be increased so that revenue raising and deterrence are achieved. The administering agency would have some discretion in setting the fines, but some degree of uniformity should also be strived for. Money from the fines can be used to provide subsidies to convert vertical seawalls to buried structures mauka of the certified shoreline.

The State should develop procedures so that all beachfront homeowners who are in distress, and who qualify, can take full advantage of advance insurance payments under the Upton-Jones amendment. For many residents at Ewa Beach, such a program may provide additional financial protection against erosion, sea-level rise, and storm wave damage. In order to take advantage of relocation benefits, an amendment to the setback may be required.

## D. Kahala Beach

Where needed, gently sloping buried revetments should be the erosion control structure of choice for Kahala. By moving erosion barriers away from the water line, some of the beach may be recovered. The transformation from vertical walls to an unstabilized coastline, or one with gently sloping buried revetments would prepare the shoreline at Kahala Beach for a potential sand replenishment project. Conversion can take place through the use of fines and subsidies. If a sand replenishment project were to materialize at Kahala, an overlay district may be needed to help prepare the shoreline for replenishment.

# XII. IMPLEMENTATION GUIDELINES

The implementation guidelines in this report can be divided into two parts. First, there are procedures to implement a statewide comprehensive beachfront management program with beach management districts. The implementation strategy for this program relies on establishing a State agency responsible for beach management that develops many of the programs in this report. To install a fully operational beach management program may take 3-4 years, assuming all legislative and financial support is obtained. The second set of implementation guidelines relate to action the State and counties can take in the interim.

## A. Public Education - Changing Public Perception

Realistically, no action is likely on many of the programs in this report given the current level of awareness and understanding about coastal erosion and beach preservation. For example, during hearings in 1991 on House Bill 893 to establish Shoreline Stabilization Districts and extend the shoreline setback, there was oral and written testimony from various parties that the present system of beach management was effective, and no further change was necessary to protect the shoreline. During the same legislative session, there was a proposal to establish a State Office of Beaches within the Department of Land and Natural Resources. Although this bill requested the relatively small amount of $100,000 to investigate staffing and budget requirements, the bill died in the House Finance Committee. From the failure of the legislature to implement these measures, it appears that beach management is not an important public issue. This is unfortunate, because in the future, the problems associated with erosion, beach loss, and sea-level rise are likely to have ramifications equal to any other environmental issue.

<u>It is clear that any significant changes regarding beach management will require an equally significant change in perception of the problem</u>. Since implementation of the programs in this report is dependent on changing public perception, some discussion should follow on this matter.

One of the first steps in changing public perception is to emphasize the gravity of the problem. There may be a tendency to sensationalize the material in this report, and all effort to do so should be suppressed. Nevertheless, it is difficult to argue with the aerial photographs that show actual beach loss (Figs. 2 through 6); the tide gauge data (Fig. 21); or the application of the Bruun Rule (Table 6), which is a widely accepted engineering technique that relates sea-level rise and beach recession.

<u>That beach loss over the last 50 years is concurrent with, and related to, sea-level rise has serious implications</u>. It indicates that the disappearance of beaches is due not only to random erosion events, but is part of an overall long-term trend. Although local conditions may change, and a few beaches may experience short-term cycles of erosion and accretion, over the long run, the majority of beaches in the State will recede.

Not only is sea-level rise expected to continue, but projections call for an acceleration in the rise. This has even greater ramifications, since beaches are very sensitive to small changes in water level. The estimates in Table 3 call for a significant acceleration in the present rate of sea-level rise by the year 2050. These estimates should be used as maximum projections. It is probable that future sea-level rise will fall between the current rate of sea-level rise and the 2050 projection. <u>Even at the current rate of sea-level rise, all gently sloping, narrow beaches in the State that have been armored, could be lost in the next 50 years</u>. The loss of beaches, as documented in Chapter 2, are exactly the changes to be expected. A continuation of the present trend would affect the integrity of coastal property, diminish recreational opportunities for the public, and impede the tourism based economy. If sea-level rise were to accelerate, as projected, the impacts would be unimaginable.

The problems with sea-level rise are sufficiently serious to warrant the development of a public education program. The program should target the general public as well as government officials and politicians. Not until the public is educated can political support be gained to implement effective beachfront management programs. In the process of informing the public, it is equally important to address the concerns of landowners. It needs to be emphasized that given the problems with sea-level rise, many of the programs would benefit the landowner.

**B. State Agency Responsible for Beach Management**

<u>The single most important step that the State can take to implement the ideas and programs in this report is to establish a State agency responsible for beach management</u>. Before there is any State Beach Fund, shoreline transfer tax,

sand replenishment, capital improvements within a Beach Management District, voluntary relocation program, or variable erosion shoreline setback, there would need to be an administering agency at the State level. The agency could be formed as an office, a division, or a branch. Alternatively, an existing State agency can be given considerably expanded duties.

There must be extensive planning prior to the designation of the appropriate agency. A bill should be submitted in the 1993 legislative session to fund this planning. Within one year after the appropriation of funds, a report should be submitted to the legislature on recommendations for the structure, organization and association of the responsible State agency, along with proposed legislation to establish that agency.

The report would need to cover many issues, including the following:

New State Agency vs. Existing State Agency - Recommendations would be needed on whether a new State Agency, such as a Division of Beaches, should be formed as opposed to expanding the duties in existing agencies. The advantage of using existing agencies is that another bureaucracy may not be required, if the capability currently exists. This could reduce manpower, cost and overhead. The disadvantage of using existing agencies is that beach management can be compromised. Preexisting duties that an agency has may take precedence over beach preservation. This could lead to "business as usual."

The advantage of forming a new State agency is that it can devote its entire effort to beach management. In the future, the problems associated with sea-level rise will be a major challenge for the State. The administration of programs that deal with these problems may require the formation of a new Division (see Chapter IX for likely scope of duties). In the long run, overall cost for a new Division may be less, if it is more effective in preventing coastal hazards, developing low cost erosion mitigation technology, or obtaining Federal funding.

Government Coordination - The report should investigate the coordination between the counties, DLNR, DOT, CZM and the Corps of Engineers for all the programs discussed in Chapter IX, as well as others that may be established. It is anticipated that the duties for different programs will be shared between the counties and the State. For example:

For capital improvements within a Beach Management District, it is anticipated that the State would pursue Federal funding, evaluate the technical, economic, and environmental viability of the project, provide permitting assistance, offer technical assistance, and pay for a major part of the cost through a State Beach Fund. However, many questions remain. For example, should the State or county determine the boundaries of the District, collect the landowner share of the cost, or obtain landowner consent?

In the administration of a variable rate erosion setback, it is anticipated that a State agency would set the appropriate shoreline setback based on the average annual erosion rate or the historical range in the position of the vegetation line. However, the counties would need to offer compensating land use variances if the setback was greater than 60 feet. How would the duties of the State and counties be shared with regard to administration of the shorline setback?

These coordination issues, and others, would need to be covered in the report. How the duties are split between the counties and the State may determine the final structure of the responsible State agency.

Staffing and Budget - The legislative report should provide some flexibility to adjust staffing and administrative costs at a later date, depending on what programs are actually implemented. Therefore, the report should include temporary and permanent budget levels for staff and administrative cost.

### C. State Agency Implements a Beachfront Management Program

Once there is a responsible State agency, it can devote the time and energy to work out the specific details that are required to implement beachfront management programs. This report briefly studied many of the programs that the agency should investigate and develop. This report is not meant to take the place of detailed investigation that the agency can conduct. Nevertheless, some preliminary implementation guidelines follow.

Capital Improvements Within a Beach Management District - The State agency would need to draft improvement district regulations for Beach Management Districts. The agency can be guided by recommendations in Chapter XI, as well as improvement district regulations for Oahu, the Hawaii Community Development Authority, and other coastal states such as Maryland, Rhode Island or North Carolina. If the improvement district is established at the State level, legislative approval would be required. The counties are currently set up to establish improvement districts.

State Beach Fund - Legislative approval is required to establish a State Beach Fund. Legislative language can be modeled after the 150-200 dedicated funds that are established in the State. These funds cover topics from Agriculture, Airports, the Aloha Tower, Animals, Aquaculture, Art, Attorneys, and Bikeways . . . . to Underground Storage Tanks, Water Pollution, Water Supply and Workers Compensation. Dedicated Funds have been established either in the state treasury (e.g., Commerce and Consumer Affairs, Compliance Resolution Fund - HRS-26-9) or within the administering Department itself (e.g. Leaking Underground Storage Tank Fund - HRS-342L-51). Statutes on beach funds from other coastal states can be used to provide additional guidance (see Chapter VII).

Beach Enforcement Fund - If the State were to conduct enforcement activities, then a Beach Enforcement Fund should be established at the State level. Alternatively, the State Beach Fund could be used to support enforcement activities. It would be the responsible State agency that could determine whether one or two funds would be required after consideration of legal and administrative matters.

Shoreline Setback - A new shoreline setback would require legislative approval. One to two years after the formation of a lead State agency, a bill for a new shoreline setback could be submitted to the legislature. Before the submittal, the State agency and counties would need to develop land use strategies that allow buildable area to be preserved while increasing the shoreline setback. These strategies would include a package of compensating zoning variances, a program of Transferable Development Rights (TDR's), a new Shoreline Zone that can be added to the State Land Use Classification scheme, or the use of an overlay district to define areas exempt from specific zoning controls.

Shoreline Transfer Tax - The Shoreline Transfer Tax would require further study to address additional legal, administrative and economic issues. At the same time that the shoreline transfer tax is studied, all other economic incentive and disincentive strategies discussed in this report should be evaluated. Some shoreline tax package could be passed one to two years after the formation of a State agency responsible for Beach Management.

Voluntary Relocation - Within one to two years after the formation of a lead State agency a report and bill could be sent to the legislature on establishing a voluntary relocation program between the State and FEMA. This program would be dependent on the amount of revenues in the State Beach Fund, which in turn, depends on the implementation of a Shoreline Tax Package.

**D. Interim Measures**

The following measures can be implemented independent of a beachfront management program administered by a State agency.

1. State. The Office of State Planning, as lead agency for the Coastal Zone Management Program, has the duty to monitor the activities of State and county agencies to ensure that they adhere to the CZM objective and policies. It is suggested that a new objective and policy be added to HRS-205A-2 that specifically addresses the problem of beach loss and sea-level rise. This would require a legislative amendment.

2. County. The following interim measures could be implemented at the county level:

a. Overlay Districts. Overlay districts can be established that control the types of erosion control structures along the shoreline (HRS-46-4). The county could develop a specific erosion control design that is suitable to the conditions in that district. By the use of an overlay district, a beach enforcement fund, and a system of fines and subsidies, it is possible to convert from the use of seawalls, to erosion control structures that fit the district design. Such a conversion can temporarily recover a lost beach and, where appropriate, prepare the shoreline for sand replenishment. For an overlay district to be formed on Oahu, it would require an amendment to the Land Use Ordinance. This would also require review by the City Planning Commission, the Department of Land Utilization, and the City Council.

b. Improvement Districts. Improvement districts could be implemented at the county level without the help of a State agency. The counties have the power, through the State Enabling Act (HRS 46-1.5), to establish improvement districts.

On Oahu, the formation of an improvement district for beach improvements would require an amendment to Oahu's Special Assessment Ordinance (City and County of Honolulu, Revised Ordinances of Honolulu, Chapter 24). In addition, the level of landowner consent should be adjusted from the present level of 60%, to a higher level, most likely 80-100%.

For an improvement district without State assistance, each of the counties would have to provide their own technical and administrative staff to support BMDs. It would be up to the county to pursue Federal funding. Most likely, only limited erosion control measures can be implemented. This may still be preferable over the current options available to the individual landowner.

The county should investigate the possibility of using improvement districts to help landowners convert legal and nonconforming vertical seawalls to buried revetments on private property. This would be a new twist on the improvement district concept, since most districts are created to finance improvements on public land that benefit the private party. Nevertheless, the language in Oahu's Special Assessment Ordinance leaves open the possibility of forming improvement districts for a valid public purpose.

Without State assistance, the cost allocation for improvements within a district would need to be changed (the suggested allocation with a lead State agency is - State 60-45%; Counties - 10%; and property owners 45-30%). Furthermore, the landowner may have to pay a higher amount for an improvement on their own property. After all the cost adjustments, a county improvement district that converts seawalls to buried erosion control structures may not be significantly different than the establishment of an overlay district with a system of fines and subsidies.

c. Overlay versus Improvement Districts. For implementation purposes, the use of an overlay district, beach enforcement fund, and system of fines and subsidies to convert seawalls to buried erosion control structures may be ideal when: a) the landowners cannot cooperate; b) there are long, alternating stretches of shoreline where seawall conversion may not be possible (e.g. there is no room to build a buried structure). The use of a county improvement district to convert seawalls to buried structures may be preferable when coastal factors and strong landowner cooperation allow a long stretch of shoreline to be converted from seawalls to buried structures.

# XIII. CONCLUSIONS

The formation and administration of Beach Management Districts involve many complex issues such as cost allocation, sources of funding, viable erosion mitigation measures, and landowner cooperation. Because of the complexities, district formation will not occur by the initiative of landowners alone. The experience in Hawaii, and other coastal states, is that landowners would rather act on their own. Furthermore, the counties may not have the technical personnel to organize a district, nor the finances to create sufficient economic incentive. In the study of beach districts for other coastal states, it became apparent that a government agency is needed to actively promote, coordinate and administer the districts. Thus, the formation of a responsible State agency is recommended in Hawaii. Once the agency is formed, it can not only establish BMDs, but could also administer a statewide beachfront management program.

The problems associated with sea-level rise are serious. The response by the State should be just as serious. Given an agency devoted to beach management, new ideas, technologies, and funding schemes could be developed to restore or preserve beaches within the district setting. For example, if the environmental problems can be resolved, Kahala Beach could be restored at a relatively low cost to the State, county and landowner. Such a project could benefit all parties. Similar projects may be possible, with some modification, at Ewa, Lanikai, Laniloa and Portlock on Oahu; Waipoli Beach on Kauai; and Waimahaihai Beach on Maui.

Past efforts to address the coastal erosion problem have been blocked by coastal landowners who have felt the government is intruding on private property rights. In this study great efforts are made to address the concerns of the landowner. Many of the programs in this report would be beneficial to both the private property owner and the public. In Tables 10 to 14, the burdens and offsetting benefits to each affected party are summarized. These summaries assume all the proposals in this report are implemented.

The reaction to these programs by the public and the landowners remains to be seen. Our initial discussion with landowners is that they would be receptive to new programs to help them deal with coastal erosion and wave attack. Further discussion is needed with various groups to modify, amend, refine or discard the proposals in this report.

To the extent that the State, counties, landowners and public can cooperate, great strides can be made to solve some of the predicted problems with sea-level rise. Without cooperation, everybody will lose. If the State can find a way to effectively balance the concerns of the public, the private sector, and the counties, they should seize the opportunity. It may take increased administrative effort and some financial commitment, but the investment would be well worthwhile.

Table 10 - Benefits and Burdens to the Owners of Developed Land

| Benefits | Burdens |
|---|---|
| A 1% to 2% reduction in real property assessments is proposed for beachfront landowners who are in compliance with coastal regulations. Such a reduction would benefit the long-term homeowner since they may receive a reduction in county property taxes every year. | A 2% property transfer tax is proposed on the sale of a beachfront property. This tax only applies to the buyer of the property, not the present homeowner. The tax is to go into the State Beach Fund. The tax may burden short-term landowners and speculative purchasers. |
| Where it is feasible, the State and county would participate with homeowners in the construction of a Beach Management District, to provide long-term protection to the coastal landowner, while preserving the beach. The landowners fractional cost of participation in a BMD may be less then the full cost to construct a seawall or revetment. Projects within the BMD may increase the value of coastal property. | A limitation would be placed on the construction of seawalls. Where hardening of the shoreline is required, buried structures such as revetments will be the shore protection of choice. |
| The State or county may provide subsidies to convert vertical seawalls to gently sloping buried structures. | Fines would be placed on illegal seawalls. |
| Money from the State Beach Recovery Fund and FEMA may be available to give landowners the option of moving off the beach if they are threatened by erosion or storms. Landowners should view this program as a form of financial protection. | |

Table 11 - Benefits and Burdens to the Owners of Undeveloped Land

| Benefits | Burdens |
|---|---|
| The proposed Division of State Beaches would provide technical assistance to the developer in dealing with erosion. The Division would help the landowner in obtaining the proper coastal permits for a erosion control project. Through the use of binding interagency agreements, master application forms and perhaps one window permitting; additional protection of the shoreline is possible with less "red tape". | There is one additional office that the large landowner or developer may have to deal with. |
| The Division of State Beaches would work with the landowner to establish a suitable setback. Where previous studies are applicable, the coastal landowner may not need an additional study. | In certain circumstances, the landowner may have to conduct a coastal erosion study to determine a suitable setback for their project. |
| Buildable area is preserved for all shoreline setbacks proposed. Where setbacks greater than 60 feet are needed to protect the beach, the counties could develop a package of compensating variances that allow increased height, a smaller front or side setback, or increased density. The net effect is to preserve buildable area even after the increased shoreline setback is imposed. Another way to reduce the economic burden includes a program of transferable development rights on other properties. The setback may be reduced for pre-approved and pre-financed erosion mitigation projects that preserve the recreational beach. | Shoreline setbacks are increased from 40 feet to 60 feet for new subdivisions and for land that is nonurban according to the State Land Use classification scheme. On eroding or unstable beaches, the shoreline setback may be larger. In no case will be the setback be larger then necessary for the State to protect the beach resource. |

Table 12 - Benefits and Burdens to the County

| Benefit | Burden |
| --- | --- |
| The residents of the county would benefit from improved recreational use of the beach. Preservation of the beach helps to preserve the tourism industry for the individual counties. | The county would pay 10% of the cost of a Beach Management District. The county would provide a 1% to 2% reduction in real property assessments for beachfront homes that are in compliance with all coastal regulations. |
| Improvements within a Beach Management District may increase the value of beachfront homes, thereby offsetting any reduction in property tax revenues caused by a 1-2% reduction in real property assessments. | |
| When narrow strips of private land are makai of county infrastructure, the county benefits by a joint State-county-landowner erosion control project that protects the landowner from erosion. | |
| The county would receive technical, and financial assistance by the State in dealing with coastal erosion. This assistance may become critical if the current rate of sea level rise were to accelerate. | |

Table 13 - Benefits and Burdens to the State

| Benefit | Burden |
|---|---|
| Preservation of beaches by the State protects a key attraction of visitors to the islands. Thus the number one industry in the State, tourism, benefits. | Legislative appropriations will be needed to establish the Division of State Beaches and to fund the State Beach Fund. The State would pay 60% to 45% of a Beach Management District. |
| Protection of beaches fulfills the State duty as trustee of coastal resources. | Greater administrative effort is required of the State. |
| Revenue for improvement projects can be derived from landowner, county and Federal contributions. Significant revenues are also possible from a shoreline transfer tax. | |
| The comprehensive plan presented in this report would help to mitigate the serious problems associated with rising sea-level. | |

Table 14 - Benefits and Burden to the Public

| Benefit | Burden |
|---|---|
| Some beaches that were lost may be returned to the public. Beaches that are presently threatened can be preserved. | Some taxpayer money would be needed to restore and preserve beaches. |
| By preserving or restoring beaches, the scenic beauty and recreational value of the coastline is protected for future generations in the State. | |
| Preservation of beaches is required to protect the tourism industry, from which all members of the public benefit. | |

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